



via overnight mail and electronically

June 7, 2013

Michelle Kerr
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**Re: CRS Site Draft Technical Impracticability Assessment
Response to U.S. EPA January 22, 2013 Comments
United States of America v. AK Steel Corporation et.
al. Case No. 1:10-cv-00996-KMO
Chemical Recovery Systems Site, Elyria, Ohio**

Dear Ms. Kerr:

On December 17, 2012, the Settling Performing Defendants in the Chemical Recovery Systems, Inc. (CRS) Site (the Site) Remedial Design/Remedial Action (RD/RA) Group (the Group), submitted a draft Technical Impracticability Waiver Assessment (the TI Assessment) to the United States Environmental Protection Agency (USEPA). During a January 3, 2013 teleconference with the Group, USEPA presented and discussed their preliminary comments on the TI Assessment. In a letter dated January 22, 2013, the USEPA provided questions and comments on the TI Assessment. Enclosed are Group responses to USEPA's January 22, 2013 comments that were not related to the Human Health Risk Assessment ("HHRA") and the Screening Level Ecological Risk Assessment ("SLERA").

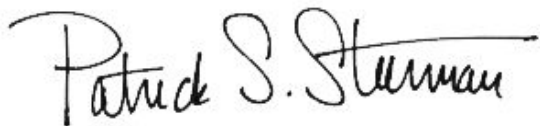
On April 10, 2013, the Group provided draft responses to USEPA's comments on the HHRA and the SLERA. The draft responses were discussed in a May 22, 2013 conference call with USEPA. The Group is in the process of supplementing and finalizing these responses based on discussions during the conference call. It is expected that responses to HHRA and SLERA comments may be submitted as soon as June 14, 2013.

If you have any questions or comments, please feel free to contact the undersigned at (770) 992-2836, or by electronic message to psteerman@charter.net.



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Best Regards,

A handwritten signature in black ink that reads "Patrick S. Steerman". The signature is written in a cursive style with a long horizontal line extending from the end of the name.

Patrick S. Steerman
CRS Site Project Coordinator

cc: Larry Antonelli, Ohio EPA (electronic copy)
Richard Karl, Director, Superfund Division EPA Region 5 (electronic copy)
Nigel Goulding, EHS Support (electronic copy)
Larry Mencin, CRS RD/RA Group, Technical Committee Chair, (electronic copy)
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June 6, 2013

Patrick S. Steerman
CRS Project Coordinator
Steerman Environmental Management & Consulting
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RE: Response to EPA Comments on Draft Technical Impracticability Waiver Assessment Report
United States of America v. AK Steel Corporation et. al. Case No. 1:10-cv-00996-KMO
Chemical Recovery Systems Site, Elyria, Ohio.

Dear Mr. Steerman:

On December 17, 2012, the Settling Performing Defendants in the Chemical Recovery Systems, Inc. (CRS) Site (the Site) Remedial Design/Remedial Action (RD/RA) Group (the Group), submitted a draft Technical Impracticability Waiver Assessment (the TI Assessment or "TIA") to the United States Environmental Protection Agency (USEPA). During a January 3, 2013 teleconference with the Group, USEPA presented and discussed their preliminary comments on the TI Assessment. In a letter dated January 22, 2013, USEPA provided questions and comments on the TI Assessment. On April 10, 2013, the Group provided a partial set of responses to USEPA's comments on the Screening Level Ecological Risk Assessment (SLERA) and the Human Health Risk Assessment (HHRA), which include comments 16-37 and 41-42 of USEPA's comment letter. The Group included preliminary results from supplemental assessments and modeling that will be further refined and included in revised risk assessment reports.

On April 19, 2013, the Group presented an analysis of the applicability of NCP standards for Technical Impracticability Waiver decisions on containment remedies so that we could better understand the role of cost and risk when responding to USEPA comments that asked the Group to evaluate additional remedial actions. In a letter dated May 7, 2013, USEPA agreed that it was appropriate for the Group to evaluate containment of the TI Zone and other remedial measures proposed in USEPA's comments using the nine NCP criteria including cost and timeframe. That response helped the Group frame its responses to the remaining USEPA comments.

This letter provides responses to USEPA's remaining comments on the TI Assessment. For ease of review, this letter restates USEPA's comments below in *italics* followed by the Group's response.

General Comment

The agencies believe that the CRS site is an appropriate candidate for a Technical Impracticability (TI) waiver of Applicable or Relevant and Appropriate Requirements (ARAR) for groundwater. However, the draft TIA does not give sufficient justification on three significant points: 1. The proposed lateral extent of the TI zone, particularly for the areas outside of the area where there is evidence of non-aqueous phase liquids (NAPL); 2. The restoration potential of the aquifer, specifically NAPL removal and hydraulic containment; and 3. Rationale for each specific contaminant of concern proposed to get a waiver. Note that we are in agreement with the conceptual site model (CSM) outlined in the revised Additional Groundwater Study (AGWS) report.

Group Response:

The Group concurs with USEPA's statement that the Site is an appropriate candidate for a TI waiver of ARARs for groundwater. Further discussion of the justification for the proposed lateral extent of the TI zone, the restoration potential of the aquifer, and the rationale for waiver of each contaminant of concern are included in the responses to other comments below.

Comments on Geologic Assessment

1. Extent of TI Zone

It is stated in Section 3.1, "The rationale for the inclusion of specific wells and areas within the lateral extent of the TI zone is summarized in Table 3-1." Table 3.1 is a "List of Constituents and Rationale for Inclusion in ARAR Waiver", not rationale for the lateral extent of the TI zone. The absence of rationale for the lateral extent of the TI zone is a fundamental deficiency in this document. There is implicit rationale for making the areas of NAPL (i.e., the red and green areas of Figure 4-9, Inferred Lateral Extent of NAPL Impacts) a TI zone; this rationale should be explicitly mentioned here. If the TI zone is to be extended laterally beyond the NAPL-impacted area, considerable rationale and supporting discussion (particularly south and north of the NAPL impacted area) is needed.

In the teleconference with the Group on January 3, 2013, we raised the lateral extent issue and the Group's consultant discussed four criteria for defining the lateral extent.

- a. The area of NAPL extent, the red area in Figure 3-1 of the TIA: we concur with this reasoning (however, see bullet c).*
- b. Down-gradient areas (represented in part by the blue arrows on Figure 3-1, but extending as far as MW-11 A) where advective flux is transporting contaminated groundwater out of the NAPL area: The TIA does not propose to hydraulically contain any of the groundwater and prevent contaminated groundwater from continuing to leave the NAPL area. For the area west of the NAPL area (riverbank), it likely would be impracticable to contain all the groundwater from the NAPL area. However, is it technically impracticable to contain groundwater flowing to the northwest?*
- c. The presence of a dissolved phase halo due to matrix diffusion that surrounds the NAPL area: we do not agree with this argument. The AGWS did not provide evidence for matrix diffusion. If matrix diffusion is a factor at the site, it is a small spatial scale phenomenon, governed by concentration gradients that occur at scales of centimeters to millimeters. In our opinion, it is likely that the extent of NAPL as provided in Figure 3-1 already contains a buffer.*
- d. Uncertainty regarding what might be found southeast and northeast of the NAPL area: The argument is based on what a manufactured gas plant (MGP) facility likely would include and that investigations have not so far identified all portions that would be sources of contamination. This criterion is unacceptable for purposes of defining the TI Zone. The areas in question have not been investigated. One of the presumptions of a TI Waiver is that contaminant sources have been identified to the extent practicable. This argument implies that not all contaminant sources have been identified. Please give consideration to the appropriateness of delaying the TI Waiver determination until after further investigation of the areas southeast and northeast of the NAPL area is complete, or shrinking the lateral extent of the TI zone in these areas if the determination will not be delayed.*

Group Response:

The Group will revise the lateral limits of the TI zone in response to USEPA's comment. USEPA found

the TIA justification sufficient for the inferred extent of NAPL marked on Figure 3-1 in red. The modeling described later in this response supports expanding the lateral extent of the TI zone to include the area of dissolved phase impacts down-gradient of the NAPL area to the west and northwest (including the area of wells MW-11a, MW-11b and MW-12). The NAPL and down-gradient dissolved phase areas are inextricably linked.

Diffusion from areas of high concentration is important at this site especially in areas proximal to the NAPL. Evidence of diffusion is observed in well MW-16 located upgradient but proximal to an area of NAPL impacts. Naphthalene, Trichloroethene (TCE) and Tetrachloroethene (PCE) have been detected in groundwater samples collected from well MW-16 at concentrations exceeding the remedial goals (MCLs). The presence of Naphthalene (a key constituent in manufactured gas wastes) and the relative concentration ratios of these compounds (concentrations of TCE and PCE an order of magnitude higher than Naphthalene which is consistent with the effective solubility of the NAPL) suggest the exceedances of remedial goals is attributable to proximal NAPL sources. On this basis, we propose the TI area should at least extend to MW-16 on the southwestern edge of the NAPL area.

Review of the groundwater monitoring data for other wells cross gradient or upgradient of the NAPL affected area does not indicate that diffusion of contaminants from the NAPL affected area is entering these areas. Therefore, the lateral extent of the TI zone and the dissolved phase zone extending down gradient of the NAPL and into the MW-16 area is sufficient to capture the areas where diffusion is occurring.

The Group acknowledges that the lateral extent of the TI Zone cannot include areas where the investigation is incomplete. Upon further review of the data, the Group agrees with USEPA's comments around uncertainty. The lateral extent of the TI zone has been reduced and only encompasses the area of NAPL and associated dissolved phase impacts as described above.

2. Restoration Potential

The TIA has adequately demonstrated that it is technically impracticable to remove all the NAPL from the subsurface and that it is technically impracticable to restore groundwater in the NAPL impacted zone in a reasonable time frame. However, the TIA needs to address better the "extent practicable" threshold.

- a. The TIA has not demonstrated that it is not technically practicable to remove any of the NAPL. An evaluation of the restoration potential should include "A demonstration that contamination sources have been identified and have been, or will be removed and contained to the extent practicable" (EPA, 1993). For example is any excavation possible (e.g. above the bedrock in the former gasholder pits)?***

Group Response:

As detailed in the AGWS Report, the Group evaluated the potential hydraulic recovery/removal of NAPL through bail-down testing in monitoring wells MW-6, MW-7A, MW-13A, and MW-14A. When these wells were last sampled, only a thin "sheen" or "globules" were observed in two of the wells, MW-13A and MW-14A, indicating that a measurable volume of NAPL had not accumulated in the wells over the months between sampling. Measureable NAPL was not observed in wells MW-6 and MW-7. No in-flow of NAPL was observed in the wells after removal of NAPL and some groundwater. Further, no measurable volumes of NAPL were measured in the wells days after these tests. These evaluations are consistent with the petro-physical testing that simulated both recovery

and aggressive displacement methods (e.g. water flood) and demonstrated that the NAPL cannot be practicably removed from the bedrock.

Areas of the site underlain by NAPL in bedrock are now covered by fill material added many years after the close of the MGP operation. The only presence of residual NAPL observed in soils has been at the upper contact of the bedrock on the eastern side of the former gasholder area where it appears that the gasholder area was excavated to just above bedrock and filled. These NAPL impacts are confined to a thin veneer of soils and fill at the bedrock/fill interface.

USEPA has asked that the Group evaluate whether it is technically practicable to excavate and remove this thin layer of NAPL-impacted soil. The Group has evaluated this additional remedial measure under the nine NCP criteria, consistent with USEPA's May 7, 2013 letter, and determined that excavating this NAPL would increase short-term risk to human health without a corresponding long-term benefit. For the reasons below, excavation of the gasholder pit is not practicable or recommended:

1. The NAPL mass within the soil is very limited and makes up a very small proportion of the total NAPL mass in the system. As such, excavating this soil does not materially improve long-term effectiveness or materially reduce toxicity, mobility or volume.
 2. Consistent with the findings of the LNAST modeling, the removal of this small NAPL mass would not result in changes in groundwater quality or measureable reductions in plume longevity.
 3. The excavation of over 15 feet of soil to access this NAPL-impacted soil zone that is less than 1 foot thick is not considered practicable or implementable based on the limited size of the site (for stockpiling and management of both clean and contaminated soils).
 4. Exposing this NAPL to oxygen by excavation increases the potential vapor risks posed to workers and adjacent properties during excavation. Transport of excavated soils poses additional costs and risks along the route to the ultimate disposal site. Excavation to address NAPL-impacted soil increases the net risk associated with the Site and is not a remedy that can be justified under the NCP criteria.
 5. USEPA assessed the NCP criteria when it issued its Record of Decision and concluded that residual soil contamination could remain in place under a soil cap with institutional controls to limit excavation at the Site. The ROD's cap and control approach was accepted by the state and by the community. The NCP criteria applied to the residual NAPL impacts in the gasholder area result in the same conclusion that additional excavation of residual soil contamination is not justified.
- b. The TIA has not demonstrated that it is not technically practicable to limit the migration of contaminated groundwater from the NAPL impacted zone and restore the aqueous plume outside the NAPL impacted area in a reasonable timeframe. The Group needs to evaluate whether it is technically practicable to hydraulically contain groundwater northwest of the NAPL area or not. The guidance states, "Where sources can be effectively contained, the portion of the aqueous plume outside the containment area generally should be restored to the required cleanup levels" (EPA, 1993). The ability to effectively contain the source should be evaluated in the TIA to determine if monitored natural attenuation could restore the aqueous plume in a reasonable timeframe. This issue affects the extent of the TI Zone.***

Group Response:

USEPA confirmed that containment remedies for a TI zone must be practicable and justified under the NCP criteria. USEPA has indicated that it is not practicable to provide hydraulic containment to

the west where the NAPL extends up to the edge of the Site and abuts the East Branch of the Black River. As discussed below, the NAPL area and the dissolved phase area are inextricably linked and, thus, we propose that they be considered part of a single TI zone. Including the dissolved phase area extends the lateral extent of the TI zone approximately 150 feet down-gradient of the NAPL area, which adds less than 0.5 acres to the TI zone. The proposed TI zone is bounded by the storm sewer line to the north and the river to the west. There is no indication of dissolved phase impacts north of the storm sewer line, indicating that additional hydraulic containment is not necessary north of this line. USEPA has already determined that it is impracticable to use hydraulic containment adjacent to the river. Importantly, we have not found any evidence of dissolved phase groundwater concentrations from the Site adversely affecting surface water quality. Thus, hydraulic containment is unnecessary for the TI zone.

The Group conducted supplemental modeling to assess the interactions between NAPL and groundwater down-gradient of the NAPL. This modeling used the same assumptions and input parameters detailed in the Groundwater Modeling Appendix of the TI Assessment. The groundwater modeling demonstrates that the dissolved phase flux from the source area is sufficient that dissolved phase impacts down-gradient of the NAPL (in the MW-11A/B area) will persist for greater than 100 years and in many cases greater than 200 years. The outputs from the modeling are summarized in Table 1, with information on the modeling approach including outputs from the BIOCHLOR model provided as Attachment 1. It would be impracticable to actively remediate this small 0.5-acre area to address hundreds of years of dissolved phase impacts.

Installing hydraulic containment upgradient of this 0.5-acre area is impracticable and cannot be justified under the NCP criteria for remedy selection.

1. The groundwater modeling indicates that hydraulic containment of groundwater would have to be conducted indefinitely (greater than 100 years) to protect this 150 ft x 150 ft parcel from the NAPL impacts. USEPA considers these very long restoration timeframes (e.g., longer than 100 years) indicative of constraints to effective remediation. See TI Guidance at p.16. The cost of operating active hydraulic containment indefinitely is impracticable and cannot be justified under the NCP criteria.
 2. Shutdowns or termination of system operations will result in flux of constituents out of the NAPL source area, which would result in exceedances of the groundwater remedial goals. Thus, perpetual containment is not a practical permanent or effective long-term remedy.
 3. The dissolved phase flux to the River is not causing adverse impacts to surface water quality and does not increase risks to human health or ecological receptors in excess of acceptable standards. Moreover, hydraulic containment on the northern boundary of the TI zone may actually increase the discharge of dissolved phase constituents to the river by channeling more groundwater across the uncontained western boundary of the TI zone along the River.
 4. The ROD already protects human health and the environment from the groundwater in this 0.5-acre area. A restrictive covenant has been established on the entire site limiting groundwater use and limiting site uses to commercial/industrial.
 5. Indefinite groundwater containment is not practicable for this site considering the discussion above and the inability of this technology to remediate groundwater within a reasonable period of time. Hydraulic containment does not satisfy the NCP criteria for remedy selection.
- c. The AGWS Report included data from permeability testing conducted on bedrock wells at the site. The information showed that nearly all of the wells could sustain injection rates of several thousand gallons of fluid on a daily basis at relatively low pressures. This would suggest that*

ground water could be remediated by extraction and treatment in areas of the site where restoration may be feasible. Being that significant volumes of water can be flushed into the aquifer, is remediation based on injection of oxidants or surfactants feasible for any portion of the site? Oxidant compounds (i.e., sodium permanganate or sodium persulfate) can consume contaminants known to be present in ground water at CRS in-situ.

Group Response:

As described in TI Assessment, restoration of the NAPL affected area is not practicable or achievable. Groundwater modeling has demonstrated that removal of NAPL mass or selective removal of volatile and soluble fractions will not lead to restoration of the source area within a 'reasonable' time frame (< 100 years).

Attachment 1 provides Tables of the estimated groundwater concentrations at MW-11A down-gradient of the NAPL using LNAST source depletion modeling to define the future concentrations and flux of constituents out of the source area. Table 2.9 and Table 2.10 provide the estimated concentrations at MW-11A from BIOCHLOR modeling considering independently the contributions from NAPL with fracture zones and the intergranular porosity of the rock.

This modeling has demonstrated that any remediation efforts in the source area would provide no benefits in terms of shortening restoration time frames down-gradient of the NAPL. The flux of constituents from the NAPL (allowing for changes in NAPL chemistry over 100 years) is still sufficient to ensure that the dissolved phase concentrations down-gradient of the NAPL will continue to exceed the remedial goals for another 100 years. After a total of 200 years (100 years of mass depletion within the LNAST model and 100 years within the BIOCHLOR and BIOSCREEN models), the concentrations at MW-11A still exceed the remedial action objectives by 1 to 2 orders of magnitude. Tables 2.9 and 2.10 provide the estimated concentrations at MW-11A after 100 years of natural mass depletion.

The modeling results also demonstrate that aggressive source remediation will not restore groundwater in the MW-11A area. As described in Attachment 1, the reduction in the concentrations of key constituents by an order of magnitude between 1 and 100 years (equivalent to 90% mass depletion efficiency) still resulted in groundwater restoration time frames within the BIOCHLOR model of greater than 100 years.

Assuming that a remedial technology was available that could preferentially reduce the concentrations in groundwater a further order of magnitude (99% mass removal), and given that contaminant flux and the concentrations in groundwater at MW-11A are directly proportional to the source area concentrations, the concentrations of these constituents in groundwater at MW-11A would decrease 1 order of magnitude. As shown in Table 2.9 and Table 2.10 a one order of magnitude decrease in the concentration of Benzene and Vinyl Chloride at MW-11A would still not be sufficient to meet the remedial action objectives after 100 years.

USEPA has suggested that the use of oxidants and/or surfactants may have some benefits. However, as discussed in the Focused Feasibility Study these technologies will have limited benefits and have not been demonstrated to be successful in fractured rock or with MGP constituents. Consistent with the modeling, high mass removal efficiencies (greater than 99%) would be required before potential benefits would be observed. Given that the NAPL at this site is trapped as residuals within the bedrock and the age of the plume (greater than 100 years old), mass removal efficiencies of this order of magnitude are improbable.

Further, a major concern with both surfactant injection and the use of oxidants is the potential to introduce additional environmental and health and safety risks. Additional adverse risks include:

1. The liberation of constituents that cannot be effectively captured by any practicable containment system resulting in increased discharges of contaminants to the river.
2. The potential creation of human health and ecological risks, which currently do not exist at the Site.
3. The generation of heat and the liberation of flammable and hazardous vapors from the NAPL during oxidation.

3. Constituents proposed for the TI Waiver

Section 3.2 of the TIA discusses constituents for which ARARs are proposed to be waived. Justification for each constituent to be included in a TI waiver is on a constituent by constituent basis. While the conceptual model for the site explains inclusion of most of the constituents, some (e.g. metals, polychlorinated biphenyls) need further discussion regarding why it is technically impracticable to remediate that particular contaminant. In addition, some are attributed to what could happen in the future, which is not appropriate and raises the question of the plume stability for a TI decision.

- a. *Further explanation is needed for identifying the constituents to be included in the waiver.*
 - a. *It appears that the document is proposing inclusion of xylene, which is neither currently detected at levels above the maximum contaminant limit (MCL) nor undetected at locations where detection limits are elevated above criteria and it is likely. Why should xylene be included in the waiver?*
 - b. *It appears that the document is proposing inclusion of constituents that are not detected at levels above the MCL, only that there are locations where detection limits are higher than the MCL. Some discussion is needed on why each of these constituents should be included.*
 - c. *There are also constituents listed in Table 3-1 for which there is no established MCL; some discussion is needed for including these. Presumably, these constituents are present above some applicable cleanup level.*
- b. *The acronym ERL appears in Table 3-1. This should be defined (either in a footnote for the table or as part of the acronyms list at the beginning of the document).*

Group Response:

Table 3-1 has been revised based on USEPA's comments and is now presented as two tables Table 3-1a and Table 3-1b, which are included as Attachment 2 to this response. It should be noted that the listing of constituents to be included in the TI Assessment has changed based on this reassessment of the data.

As noted in Section 3.2, the Record of Decision (ROD) issued in October 2007 a broad range of constituents has been identified as Chemicals of Potential Concern (COPCs) in groundwater. These constituents are listed in the ROD as constituents present at the Site in groundwater and/or constituents currently exceeding MCLs as defined under the Safe Drinking Water Act of 1986.

To address the COPCs that do not have established MCLs, a hierarchy was used to outline the rationale for identification of the specific constituents within the TI zone that will be included in the TI Waiver. The hierarchy consists of both ARARs and to be considered (TBCs) applicable cleanup levels. The following ARARs and criteria were included in the assessment in the following order:

1. USEPA Maximum Contaminant Levels (MCLs). May 2009. Available online at: <http://water.epa.gov/drink/contaminants/index.cfm> Last accessed: 02/04/2013.
2. Ohio Environmental Protection Agency (OEPA). Drinking Water Standards for Ohio Public Water Systems. November 26, 2010. Ohio Administrative Code Chapter 3745-81
3. OEPA. Generic numerical standards. Ohio Administrative Code. 3745-300-08 Tables V and VI, Generic numerical standards for unrestricted potable water use.
4. USEPA Regional Screening Levels (RSLs). November 2012. Available online at: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm Last accessed: 02/04/2013

The ARARs and TBCs used in the hierarchy are presented in Table 3.1a, and the ones identified in ROD are noted.

As described within the AGWS and the TI Assessment, organic constituents associated with CRS operations have become co-eluted within the NAPL. Analytical testing of water samples containing NAPL has resulted in elevated reporting limits for many of the constituents potentially present in MGP wastes or associated with historic CRS operations. Further, the presence of a broad range of non-descript petroleum hydrocarbons results in considerable interference, further elevating the reporting limits of select constituents. On this basis, water samples with elevated reporting limits may have organic compounds associated with historic activities at concentrations exceeding the remedial action objectives for groundwater.

Similarly, the metal concentrations in groundwater are elevated above the remedial action objectives for groundwater or potentially applicable standards. The presence of highly reducing geochemical conditions (in response to the presence of NAPL) has resulted in elevated concentrations of key metals in groundwater (for example, iron and manganese)

Assessment of groundwater conditions against the criteria was conducted using the following hierarchy:

1. If the COPC concentration in the TI zone, or its maximum detection level, exceeds the MCL, it will be included in the TI Waiver
2. If the COPC does not have an MCL, if the COPC concentration, or its maximum detection level, exceeds a OEPA groundwater standard (Generic Unrestricted Potable Water Use), it will be included in the TI Waiver
3. If the COPC does not have an OEPA standard, if the COPC concentration, or its maximum detection level, exceeds an RSL, it will be included in the TI Waiver
4. If the COPC does not have an RSL, it will not be included in the TI Waiver
5. The COPCs identified for the TI Waiver using the hierarchical approach are presented in Table 3.1b.

Based on the above hierarchy, methylcyclohexane was not included in the TI Waiver because there was no ARAR or TBC applicable cleanup level. In addition, the common nutrients calcium, sodium, magnesium, and potassium were not included in the TI Waiver because that did not have any ARAR or TBC applicable cleanup level. Finally, several COPCs were not included in the TI Waiver because the detected concentrations and/or the maximum detection levels were less than the hierarchical ARAR or TBC applicable cleanup levels.

4. Section 4. L2, Hydrogeology, Page 12

The elevation-based discussion in the third paragraph is confusing and needs clarification. The text seems to imply that the LBZ is a very thin zone ("from elevation ± 684 to 668 ft. msL"). These elevations are also inconsistent with the AGWS, which defined the Lower Bedrock Zone as being generally below 667 ft., msL

Group Response:

The text will be corrected to be consistent with the AGWS.

5. Section 4. L2, Hydrogeology, Page 13

- a. It is an overreach to state in the third full paragraph that "field evidence proves that groundwater is approaching a state of horizontal flow ..." Please replace "proves" with "indicates".*

Group Response:

Comment noted and the text will be revised accordingly

- b. The paragraph goes on to imply that no underflow is possible beneath the river adjacent to the site. This contradicts the AGWS (e.g., pages 2-5 and 4-4). It is common for deeper groundwater near a small river to underflow the river, moving consistent with the regional groundwater flow pattern even as the shallower groundwater is discharging into the river.*

Group Response:

Comment noted and the text can be revised to indicate that the groundwater within the vertical interval of the TI zone does not underflow the river. Deeper, non-impacted groundwater, below the TI zone, is likely moving consistent with the regional groundwater flow pattern.

6. Section 4.2, NAPL Conceptual Model, Page 16

Mention is made of matrix diffusion. This concept was not mentioned in the AGWS. Was evidence of matrix diffusion found at the site? What was the evidence? Did contamination actually chemically diffuse from open fractures into the adjacent uncontaminated rock matrix or did contamination distributed by the groundwater flowing through the fractures and rock matrix sorb on the surfaces of the rock matrix?

Group Response:

The text of the document will be revised to better describe the matrix diffusion processes at this site.

Based on the distribution of NAPL within the inter-granular porosity of the rock and in some cases the absence of NAPL impacts within fracture zones, matrix diffusion will occur from the areas of NAPL impacts into the more transmissive fracture zones. This diffusion of mass from NAPL impacted zones to more transmissive intervals is likely to explain (in combination with dispersivity) some of the vertical and lateral distribution of groundwater impacts at the site.

7. Section 4.2.5, Natural Attenuation Processes in Groundwater, Page 29

A transect is discussed that includes MW-14A, MW-12, and MW-11. Based on the potentiometric maps provided, note that MW-14A is not upgradient of MW-12 and MW-11. Please add some language to explain that while MW-14A is not directly upgradient of MW-12 and MW-11, concentration levels at MW-14A are being considered representative of groundwater in the vicinity to the north that is upgradient of MW-12 and MW-11.

Group Response:

Revisions to the text will be made to indicate that the results for MW-14A are considered representative of the groundwater in the NAPL source area, which is located upgradient of MW-12 and MW-11.

8. Section 4.4, Summary of Conceptual Model and Assessment of Restoration Potential

- a. One row of Table 4-2 is labeled Contaminant Retardation (Sorption Potential) and refers to the low organic carbon content of the bedrock. What is the basis for the reference to the low organic carbon content of the bedrock? Was the organic carbon content of the bedrock measured? There was no mention of this in the AGWS.*

Group Response:

Literature values for organic carbon in sandstone are low (typically less than 0.1% (Freeze and Cherry, 1987)). The presence of organic carbon within the bedrock would result in sorption of contaminant mass and result in longer restoration timeframes. In order to provide the most optimistic estimate of restoration timeframes during the assessment of remediation options, the modeling assumed no retardation and sorption within the aquifer.

- b. The row of Table 4-2 labeled Volume of Contaminated Media states that "It is estimated that greater than 70,000 lbs. of contaminant mass is present as NAPL within the bedrock". What is the source for this estimate? There was no mention of this in the AGWS.*

Group Response:

The estimation of NAPL mass was based on NAPL saturations and the inferred lateral extent of NAPL impacts. The LNASt model automatically calculates NAPL mass in place and this information is included in the LNASt model output files, which have been included in the Groundwater Modeling Appendix of the TIA.

The text will be updated to reflect the source of this estimate and cross-reference the mass calculations that are included in the LNASt model.

9. Section 7.3, Focused Feasibility Study and Recommended Alternatives, Page 42

This section appears to be an attempt to propose an "Alternative Remedial Strategy". A better articulation of the alternate restoration strategy for this site is needed.

- a. It is confusing to imply that Natural Source Zone Depletion (NSZD) would be the source remedy in the area of NAPL impact. Much of this document has been a demonstration that nothing, including NSZD, is capable of remediating the source zone of NAPL in a reasonable time frame. Clarification of the role NSZD at this site is needed.*

Group Response:

The Group is not suggesting that NSZD can remediate the NAPL zone in a reasonable timeframe and we will adjust the text to make that more clear.

The Focused Feasibility Study (FFS) concludes from the literature studies that NSZD will be as effective for the CRS site conditions as more aggressive remedial technologies. However, neither will be able to remediate the NAPL zone to ARARs within a reasonable timeframe. The natural processes at work in NSZD, however, will continue to slowly reduce the mass within the TI Zone.

As outlined in the FFS, NSZD refers to natural processes including volatilization and dissolution that occur within source areas and decrease mass over time. These processes are different from those natural attenuation processes within the dissolved phase where biodegradation and dispersion are key processes that attenuate concentrations over distance and time. NSZD and Monitored Natural Attenuation (MNA) are linked with mass lost from the source area attenuated within the unsaturated and saturated zones above, below and down-gradient of the source area.

- b. MNA can indeed be an effective approach for restoration of groundwater; this generally is when contaminant sources are removed or contained. (See EPA, 1999 that states, "EPA expects that MNA will be most appropriate when used in conjunction with other remediation measures (e.g., source control, groundwater extraction), or as a follow-up to active remediation measures that have already been implemented.") As presented in this document, the only source control proposed is Natural Source Zone Depletion (NSZD), which is anticipated to take much longer than 100 years to remediate the source. No containment is proposed. MNA may be able to minimize or eliminate contaminant migration to the East Branch of the Black River. However, the NAPL source without any containment will be continuing to release contamination into the aqueous plume for an equally long time and MNA will not fully remediate the plume until after the source is gone. Clarification of the role of MNA at this site is needed.*

Group Response:

USEPA has stated that containment is impracticable in the area west of the TI zone as the NAPL impacts extend to the western boundary of the site at the river. MNA will not achieve ARARs for groundwater crossing the western edge of the TI Zone. As described in the responses above, the small 0.5 acre dissolved phase area to the northwest (towards MW-11A) is properly considered part of the TI zone source area. Dissolved phase migration has impacted this small area for 100 years or more and it will take 100 years or more for monitored natural attenuation to remediate the groundwater in this area as NSZD reduces the source area. Also as discussed above, the cost and risk of setting up a temporary barrier to shield this small area from additional dissolved phase contributions cannot be justified under the NCP criteria. The barrier would have to be maintained for over 100 years because removal of the barrier will allow the source behind it to contribute dissolved phase compounds again that interfere with attaining ARARs. The site does not need this barrier to mitigate human health or ecological risks, because the concentrations within the river are below the ARARs and the age of the NAPL in the bedrock ensures that these concentrations are stable. As such, it is impracticable and inconsistent with NCP criteria to continuously pump to maintain the hydraulic barrier for greater than 100 years. MNA continues to be the preferred remedial option for areas outside the TI Zone. Within the TI Zone, including the dissolved phase area down-gradient of the NAPL area, MNA with NSZD will gradually attenuate concentrations over many decades.

10. Section 7.3, Focused Feasibility Study and Recommended Alternatives, Page 42, Second Bullet

The second unnumbered bullet refers to the revised Remedial Action Objective (RAO). Section 5.0, Page 14 of the Focused Feasibility Study Report proposes revised RAOs. Please restate these here.

Group Response:

The comment is noted and the requested changes will be made.

11. Appendix B: Groundwater Modeling Report, Section 3.1, Modeling Transects

It is unclear why MW-10A is appropriately considered a source term for transect B. Groundwater at MW-10A is flowing west, not northwest. Further explanation is needed.

Group Response:

The comment is noted and the requested changes will be made. MW-10A is located with the source area and was selected as indicative of source area concentrations for transect B.

12. Appendix B: Groundwater Modeling Report, Section 3.2, BIOCHLOR Input Parameters and Assumptions, Source Data

Were any scenarios run in BIOCHLOR that assumed source reduction, as was done with the LNAST model?

Group Response:

It should be noted that neither BIOCHLOR nor BIOSCREEN are source depletion models. To allow simulation of the nature and extent of groundwater impacts after changes in source concentration the output data from the LNAST model at 100 years was input as the source term within the BIOCHLOR model. See Appendix B (Input and Output Parameters)

As described above, this supplemental modeling has demonstrated that after 100 years of source mass depletion, the area of groundwater exceedances is unchanged and extends through well MW-11A. Changes in groundwater concentrations are observed at MW-11A however, the concentrations of key constituents are still above the remedial action objectives.

The limited changes in the lateral extent of groundwater impacts in the BIOCHLOR model is a function of the persistent high concentrations in the source area (which the LNAST modeling has demonstrated could persist in the inter-granular porosity of the rock for greater than 1000 years) and the small size of the site (which provides for very limited travel time for biodegradation).

13. Appendix B: Groundwater Modeling Report, Section 4.0, Summary and Conclusions

It is stated that one of the things the modeling assessed was "The potential benefits (or lack thereof) of source remediation remedies on groundwater concentrations and plume longevity". LNAST evaluated the effect of source remediation on groundwater concentrations in the source area. The BIOCHLOR and BIOSCREEN modeling evaluated dissolved contaminant fate and transport down-gradient of the source area. It is unclear that the effects of source remediation on the down-gradient plume were investigated. We acknowledge that the results of the LNAST modeling indicated that even with significant source remediation levels of most contaminants in the groundwater at the source area would remain elevated even after 100 years. However, what the effect of the reduced (although still

high) levels at the source would have on the down-gradient plume did not seem to have been evaluated. It is likely that even with source reduction that the contaminant exceedances would persist down-gradient; but this is simply a presumption, it has not been demonstrated in the TIA.

Group Response:

Refer to response to 12 above. Additional modeling has been conducted which indicates that no changes in the lateral extent of groundwater impacts will be observed down-gradient of the source area. The limited changes observed in predicted groundwater concentrations down-gradient of the NAPL is a function of the ongoing flux of constituents from the NAPL and the limited distance (only 150 feet to the boundary and 120 feet from the source area to MW-11A) from the source area to the site boundary.

14. Appendix E: Focused Feasibility Study Report, Section 6.5.2, Enhanced Removal (Pump and Treat) for Hydraulic Control, Page 22

Pump and treat would not be a successful technology for source remediation at the site. However, it could be effective for source containment, limiting the migration of contaminated groundwater from the NAPL impacted zone and allowing the restoration of the aqueous plume outside the NAPL-impacted area in a reasonable timeframe. It is incorrect to assert (as is done in the last paragraph of this section) that pump and treat for hydraulic control of groundwater at this site is unnecessary. When sources cannot be removed or treated, source containment can be critical to the alternative remedial strategy.

Group Response:

The Group will revise the text indicating that pump and treat systems are unnecessary. It is appropriate, however, to evaluate the pump and treat system among the remedial options available for this site using the NCP criteria. As indicated above, temporary hydraulic containment for this small 0.5-acre area cannot be justified under the NCP given the associated cost and risk. The termination of pumping will result in the re-contamination of the down-gradient areas and not restoration of groundwater quality.

15. Appendix E: Focused Feasibility Study Report, Section 7.3, Alternative 3, Page 28

Please clarify (if correct) that the cap/cover mentioned in this alternative is the same cap/cover as was specified in the Record of Decision (ROD). It is important in the TIA that it be clear what is proposed to be deviations from the ROD (i.e. the Alternative Restoration Strategy) and what is proposed which would remain consistent with the ROD.

Group Response:

The cap outlined in the FFS is the cap approved in the ROD. The existing actions specified in the ROD and the integration of the groundwater and NAPL remedial actions has been described throughout the TIA and FFS. A detailed discussion of the ROD and the specified remedial actions has also been provided in the FFS as background.

No deviations from the remedy specified in the ROD have been proposed as part of the FFS. Excavation of designated soils, capping and institutional controls have been retained for the soil remedy and institutional controls and MNA have been retained for the groundwater remedy.

Minor Editorial Comments

38. There are numerous references cited in the document. The full citations of some references are not provided. Please provide them. For example:

Page 10, Chevron 2005, RTDF 2006

Page 16, Reynolds and Kueper 2002

Page 19, API 2003, Higinbotham et al. 2003

Page 20, RTDF 2005

Page 25, Clements et al. 2009, Zemo 2006, Lundegard and Sweeny 2004

Page 27, Bouwer and McCarty 1984

Group Response:

The above references will be inserted into the reference list of the document.

39. Section 4.1.1, Geologic Framework

In the fourth paragraph, reference is made to Figure 4-2. This is absent; please provide.

Group Response:

Figure will be inserted. A copy of the proposed figure is provided as Attachment 3.

40. Section 4.2.4, Groundwater Conditions

In the second paragraph, reference is made to Figure 4-15. Figure 4-15 is a cross section. Is Figure 4-17 the correct figure to reference?

Group Response:

The correct Figure is 4-17

43. Appendix E: Focused Feasibility Study Report, Page 8, Paragraph 3

There is an unnecessary period before "summary".

Group Response:

Comment is noted and the text will be corrected.

44. Appendix E: Focused Feasibility Study Report, Page II

There is a minor typo in the numbered list item 1; "Dese" should be "Dense".

Group Response:

Comment is noted and the text will be corrected.

45. Appendix E: Focused Feasibility Study Report, Page 18

There are several minor typos in the last paragraph: "...degradation of the these compounds are..." should be "degradation of these compounds is...". " Further, these assessments have demonstrated that the groundwater impacts are stable and that majority of groundwater", needs another "the" between that and majority.

Group Response:

Comment is noted and the text will be corrected.

46. Appendix E: Focused Feasibility Study Report, Page 21

There is a minor typo in the third paragraph: "moister" should be "moisture".

Group Response:

Comment is noted and the text will be corrected.

47. Appendix E: Focused Feasibility Study Report, Page 24

There is a minor typo in the last line of the first paragraph: "for" should be "from".

Group Response:

Comment is noted and the text will be corrected.

48. Appendix E: Focused Feasibility Study Report, Page 26

There is a minor typo in the first line of Section 7.2: "as source a remedy" should be "as a source remedy".

Group Response:

Comment is noted and the text will be corrected.

If you have any questions with the responses to any of the USEPA comments, please contact me at 412 977 4474.

Sincerely,



Nigel Goulding
EHS Support

Enclosures:

- Attachment 1
- Attachment 2
- Attachment 3

Attachment 1

Supplement to Groundwater Modeling
Source Zone Depletion at 100 years and impacts on dissolved phase groundwater concentrations

ATTACHMENT 1

SUPPLEMENTAL GROUNDWATER MODELING

Supplemental modeling was completed to assess the potential benefits of natural source zone depletion and source remediation on dissolved phase concentrations down gradient of the NAPL source area.

The input parameters for the model are summarized in **Table 2.8** and the results from the model runs are summarized in **Tables 2.9** and **Table 2.10**. Model runs were conducted for benzene, toluene, TCE, DCE, vinyl chloride, and naphthalene. Screen shots of these model runs are included for each of the simulations.

Depleted source zone concentrations were taken from the 100th year of the LNAST model results, and then ran for an additional 100 years in BIOCHLOR or BIOSCRN models (effectively for total remediation period of 200 years). This modeling simulation was completed to assess plume longevity and changes in groundwater concentrations, down gradient of the NAPL. The modeling evaluated both:

1. 200 years of natural source depletion (100 years in LNAST model and 100 years in the BIOCHLOR model); or
2. Order of magnitude decreases in source concentrations in response to remediation followed by a 100-year period of natural source depletion and biodegradation.

It should be noted that the modeling approach is conservative, as the BIOCHLOR and BIOSCREEN models do not consider the persistence of NAPL in the source area, which will provide ongoing contributions to groundwater.

As summarized in **Tables 2-9** and **2-10**, groundwater concentrations down-gradient of the source still exceed the remedial goals after greater than 100 years. Benzene, DCE, vinyl chloride and naphthalene still exceeded the remedial goals after order of magnitude reductions in concentration in the source area and an additional 100 years of natural attenuation (100 years of source depletion in the LNAST model and 100 years within the BIOCHLOR model for a total remediation period of 200 years). TCE is at the remedial objective after the 100-year model run. Toluene is below the remedial objective after the 100-year model run.

A hydraulic conductivity (K) sensitivity analysis was also performed. The original K is 5.3E-4 cm/sec. The low end K is 3.4E-5 cm/sec. The high end K is 2.5E-3 cm/sec. In all cases, the groundwater concentrations at MW-11A exceeded the remedial action objectives. These results confirm that despite the likely variability in hydraulic conductivity and with or without active remediation groundwater concentrations in exceedance of the remedial action objectives will persist at MW11A.

Model Notes

Concentrations loaded into the BIOCHLOR and BIOSCRN models were obtained from **Table 2-7 Results of LNAST Model Simulations** for Baseline Conditions after the LNAST model simulated the NAPL plume for 100 years. These concentrations were loaded into the Source Data window within the BIOCHLOR and BIOSCRN input worksheets. **Table 2-8** includes the LNAST Baseline Modeled Concentrations from **Table 2-7** and the simulated BIOCHLOR and BIOSCRN concentrations described herein.

The Modeled Area Length in the General window was changed from 220 ft. to 200 ft. for direct comparison at MW-11A, which was modeled as 160 ft. from the source area. The simulation time in the General window was changed to 100 years. No other variables were changed as these models have already been calibrated to site conditions. The Field Data for Comparison shown are relative to the initial source concentrations and are not representative of the revised depleted source concentrations. These data were included only as a comparison to previously modeled concentrations. The depleted source zone model runs were only performed on the model transect that terminated at MW-11A (as opposed to transects that terminated at MW-10A or MW-8D). The depleted source model runs were simulated for 100 years to determine if the modeled concentrations at MW-11A were below the remedial objective provided in **Table 2-9** and **Table 2-10** for the fracture zones and intergranular porosity of the rock.

If the modeled concentrations with biotransformation at MW-11A were below the remedial objective, no further action was performed. If desired, time vs. concentration curves can be constructed with incremental time steps for these model runs. Time vs. concentration curves will be constructed for instances where the modeled concentrations are below the remedial objective at the 100 year mark.

Table 2-8. Hydraulic Conductivity Values for Model Runs

Flow Model	K	
	ft/day	cm/sec
<i>LNAST</i>		
LNAST Intergranular Flow Model	0.0964	3.40E-05
LNAST Fracture Flow Model	2.61	9.20E-04
<i>BIOCHLOR/BIOSCREEN</i>		
Baseline K BIOCHLOR/BIOSCRN Model	1.5	5.30E-04
Low K* BIOCHLOR/BIOSCRN Model	0.0964	3.40E-05
High K* BIOCHLOR/BIOSCRN Model	7.09	2.50E-03

*K values taken from Figure 4-3. Cross-Section A-A'

K = Hydraulic Conductivity

Table 2-9. BIOCHLOR and BIOSCREEN Results for 100 Year Depleted NAPL Source through Fracture Flow

Constituent	Remedial Objective (ug/L) ^a	MCL or RSL?	LNAST Modeled Concentrations (ug/L)		Modeled Concentrations at MW-11A at 100 years (ug/L)	Modeled Concentrations at MW-11A with Varying K Values (ug/L)	
			1 year	100 year		3.40E-05 cm/sec	2.50E-03 cm/sec
Volatile Organic Compounds							
Benzene	5.00E+00	MCL	2.21E+03	7.86E+02	7.80E+01	3.00E+00	1.10E+02
Toluene	1.00E+03	MCL	2.10E+04	7.39E+03	2.20E+01	0.00E+00	3.04E+02
Ethylbenzene	7.00E+02	MCL	9.16E+02	4.33E+02	3.40E+01	0.00E+00	5.70E+01
Xylene	1.00E+04	MCL	4.62E+03	2.12E+03	8.00E+01	0.00E+00	2.24E+02
Trichloroethene	5.00E+00	MCL	1.16E+04	4.12E+03	5.00E+00	0.00E+00	4.40E+01
cis-1,2-Dichloroethene	7.00E+01	MCL	2.05E+04	2.98E+03	1.08E+02	3.00E+00	1.34E+02
Vinyl Chloride	2.00E+00	MCL	NA	NA	3.40E+01	8.00E+00	1.00E+01
Semi-Volatile Organic Compounds							
Naphthalene	1.40E-01	RSL ^b	3.56E+03	1.97E+03	3.00E+00	0.00E+00	2.40E+01

^aRemedial objectives taken from 2012 U.S. EPA screening level tables (U.S. EPA 2012). RSL values were used when MCL values were unavailable.

^bRSL screening level taken from Carcinogenic Target Risk (TR) = 1E-06 from U.S. EPA (2012).

MCL = maximum concentration level

RSL = risk-based screening level

Gray fill indicates exceedance of remedial objective.

K for the Fracture Flow LNAST model was 2.61 ft/day (9.20E-4 cm/sec)

Table 2-10. BIOCHLOR and BIOSCREEN Results for 100 Year Depleted NAPL Source through Intergranular Porosity

Constituent	Remedial Objective (ug/L) ^a	MCL or RSL?	LNAST Modeled Concentrations (ug/L)		Modeled Concentrations at MW-11A at 100 years (ug/L)	Modeled Concentrations at MW-11A with Varying K Values (ug/L)	
			1 year	100 year		3.40E-05 cm/sec	2.50E-03 cm/sec
Volatile Organic Compounds							
Benzene	5.00E+00	MCL	3.77E+03	1.92E+03	1.89E+02	7.00E+00	2.68E+02
Toluene	1.00E+03	MCL	2.74E+04	1.32E+04	3.90E+01	0.00E+00	5.40E+02
Ethylbenzene	7.00E+02	MCL	9.88E+02	7.07E+02	5.50E+01	1.00E+00	9.30E+01
Xylene	1.00E+04	MCL	5.03E+03	3.46E+03	1.31E+02	0.00E+00	3.65E+02
Trichloroethene	5.00E+00	MCL	1.81E+04	8.65E+03	1.00E+01	0.00E+00	9.30E+01
cis-1,2-Dichloroethene	7.00E+01	MCL	3.57E+04	1.34E+04	3.51E+02	8.00E+00	4.72E+02
Vinyl Chloride	2.00E+00	MCL	NA	NA	1.15E+02	2.50E+01	3.80E+01
Semi-Volatile Organic Compounds							
Naphthalene	1.40E-01	RSL ^b	3.53E+03	3.43E+03	6.00E+00	0.00E+00	4.20E+01

^aRemedial objectives taken from 2012 U.S. EPA screening level tables (U.S. EPA 2012). RSL values were used when MCL values were unavailable.

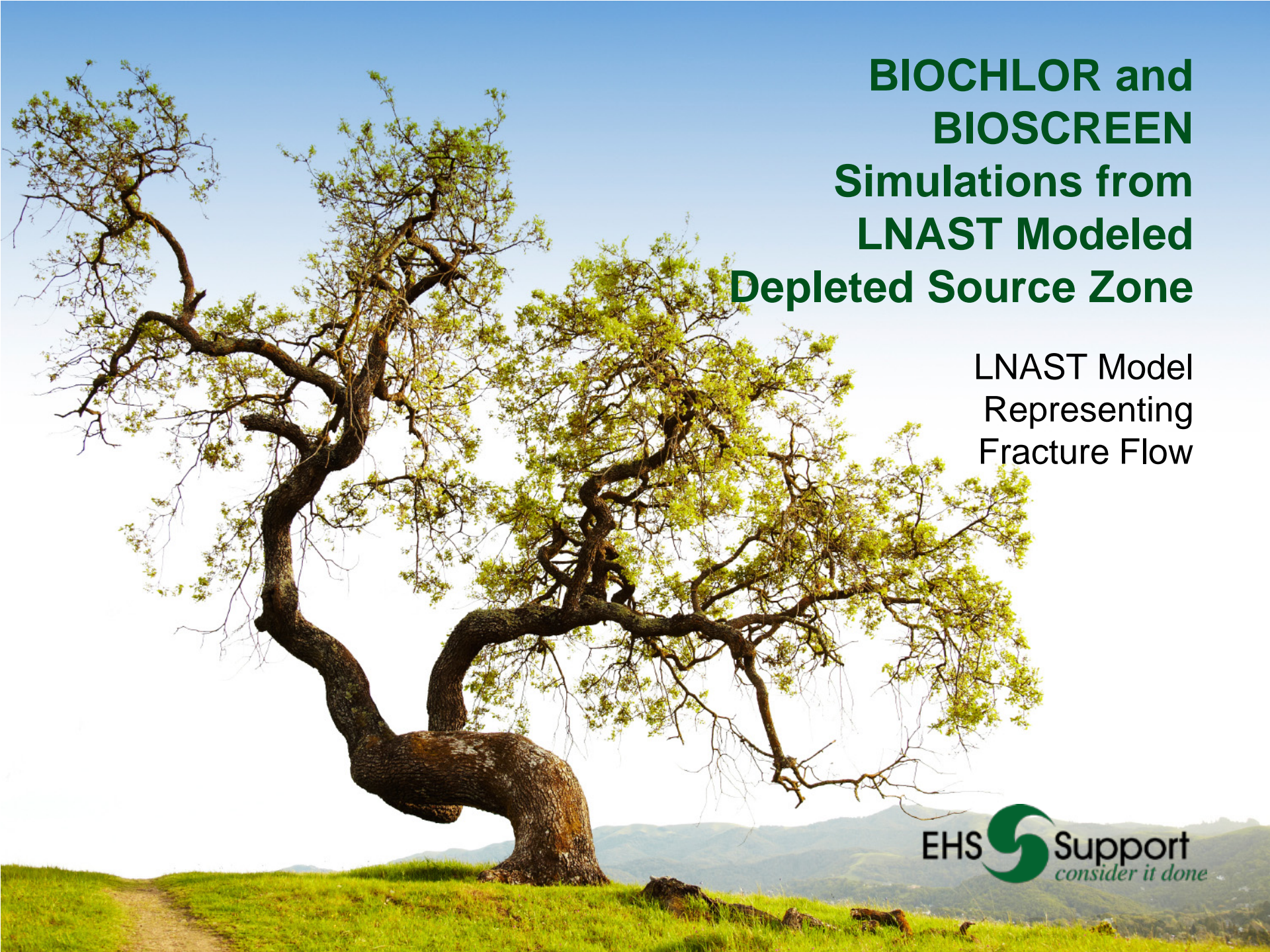
^bRSL screening level taken from Carcinogenic Target Risk (TR) = 1E-06 from U.S. EPA (2012).

MCL = maximum concentration level

RSL = risk-based screening level

Gray fill indicates exceedance of remedial objective.

K for the Intergranular Porosity LNASt model was 9.64E-02 ft/day (3.40E-5 cm/sec)

A large, gnarled tree with green leaves stands on a grassy hill under a blue sky. The tree's trunk is thick and twisted, with many branches spreading out. The background shows rolling hills and a clear sky.

BIOCHLOR and BIOSCREEN Simulations from LNAST Modeled Depleted Source Zone

LNAST Model
Representing
Fracture Flow



BIOCHLOR / BIOSCREEN Baseline K Simulations

LNAST FRACTURE FLOW

Input screen for Baseline K BIOCHLOR TCE, DCE, and VC model runs with source concentrations taken from Table 2-9

BIOCHLOR Natural Attenuation Decision Support System
Version 2.2
Excel 2000

CRS
MW-14A to MW-11A
Run Name

Data Input Instructions:
115 → 1. Enter value directly....or
↑ or 0.02 → 2. Calculate by filling in gray cells. Press Enter, then **C**
(To restore formulas, hit "Restore Formulas" button)
Variable* → Data used directly in model.
Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT:
Ethenes ☒
Ethanes ☐

1. ADVECTION
Seepage Velocity* Vs 172.2 (ft/yr) **C**
or
Hydraulic Conductivity K 5.3E-04 (cm/sec)
Hydraulic Gradient i 0.0628 (ft/ft)
Effective Porosity n 0.2 (-)

2. DISPERSION
Alpha x* 50 (ft)
(Alpha y) / (Alpha x)* 0.1 (-)
(Alpha z) / (Alpha x)* 1.E-02 (-)
Calc. Alpha x

3. ADSORPTION
Retardation Factor* R **C**
or
Soil Bulk Density, rho 1 (kg/L)
Fraction Organic Carbon, f_{oc} 0.0E+0 (-)
Partition Coefficient K_{oc}
PCE 426 (L/kg) 1.00 (-)
TCE 130 (L/kg) 1.00 (-)
DCE 125 (L/kg) 1.00 (-)
VC 30 (L/kg) 1.00 (-)
ETH 302 (L/kg) 1.00 (-)
Common R (used in model)* = 1.00

4. BIOTRANSFORMATION
Zone 1
PCE → TCE 0.000 (1/yr) half-life (yrs) 0.79 Yield 0.79
TCE → DCE 7.000 (1/yr) half-life (yrs) 0.74 Yield 0.74
DCE → VC 0.700 (1/yr) half-life (yrs) 0.64 Yield 0.64
VC → ETH 0.500 (1/yr) half-life (yrs) 0.45 Yield 0.45
Zone 2
PCE → TCE 0.000 (1/yr) half-life (yrs) **λ** **HELP**
TCE → DCE 0.000 (1/yr) half-life (yrs)
DCE → VC 0.000 (1/yr) half-life (yrs)
VC → ETH 0.000 (1/yr) half-life (yrs)

5. GENERAL
Simulation Time* 100 (yr)
Modeled Area Width* 200 (ft)
Modeled Area Length* 200 (ft)
Zone 1 Length* 200 (ft)
Zone 2 Length* 0 (ft)
Zone 2 = L - Zone 1

6. SOURCE DATA
Source Options
TYPE: Continuous Single Planar
Source Thickness in Sat. Zone* 5 (ft)
Width* (ft) 10
Y1
Conc. (mg/L)* C1
PCE .0
TCE 4.12
DCE 2.98
VC .0
ETH .0
k_s* (1/yr)
0
0
0
0
0
View of Plume Looking Down
Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON
PCE Conc. (mg/L) 1.0 .165 .032
TCE Conc. (mg/L) 16.0 .165 .019
DCE Conc. (mg/L) 50.0 8.2 .96
VC Conc. (mg/L) 1.0 .165 .48
ETH Conc. (mg/L)
Distance from Source (ft) 0 10 20 40 60 85 100 120 140 160 220
Date Data Collected 2011

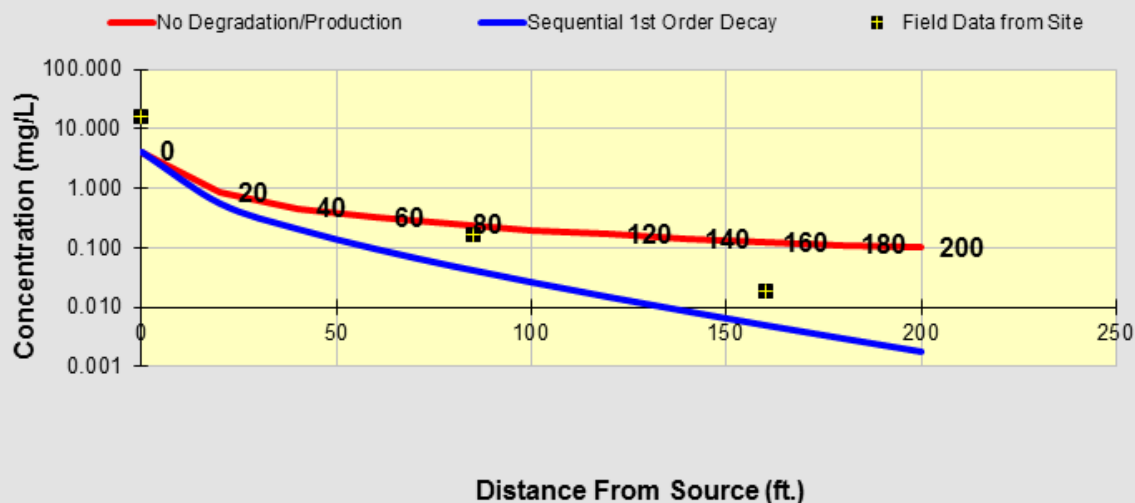
8. CHOOSE TYPE OF OUTPUT TO SEE:
RUN CENTERLINE **RUN ARRAY** **Help** Restore RESET
SEE OUTPUT Paste Unprotect

Output screen for Baseline K BIOCHLOR TCE with source concentrations taken from Table 2-9

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

TCE	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	4.120	0.838	0.464	0.321	0.245	0.198	0.166	0.143	0.126	0.112	0.101
Biotransformation	4.1200	0.560	0.207	0.095	0.049	0.026	0.015	0.008	0.005	0.003	0.002

Field Data from Site	Monitoring Well Locations (ft)										
	0	10	20	40	60	85	100	120	140	160	220
Field Data from Site	16.000					0.165				0.019	



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

100.0 Years

Log ↔ Linear

Unprotect
Sheet

Return to
Input

To All

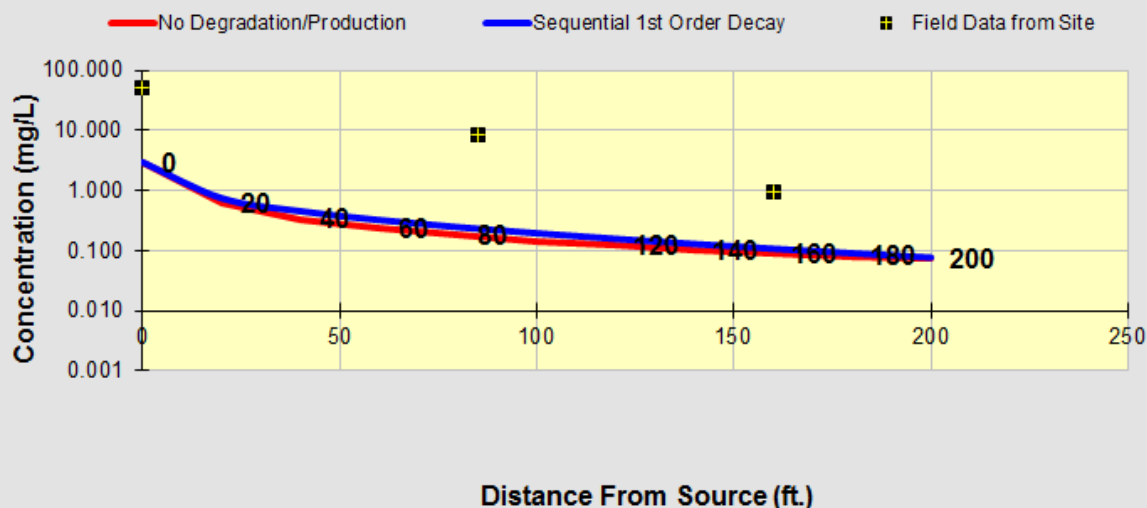
To Array

Output screen for Baseline K BIOCHLOR DCE with source concentrations taken from Table 2-9

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

DCE	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	2.980	0.606	0.336	0.232	0.177	0.143	0.120	0.104	0.091	0.081	0.073
Biotransformation	2.9800	0.748	0.454	0.324	0.247	0.195	0.157	0.129	0.108	0.090	0.077

Field Data from Site	Monitoring Well Locations (ft)										
	0	10	20	40	60	85	100	120	140	160	220
Field Data from Site	50.000					8.200				0.960	



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

100.0 Years

Log ↔ Linear

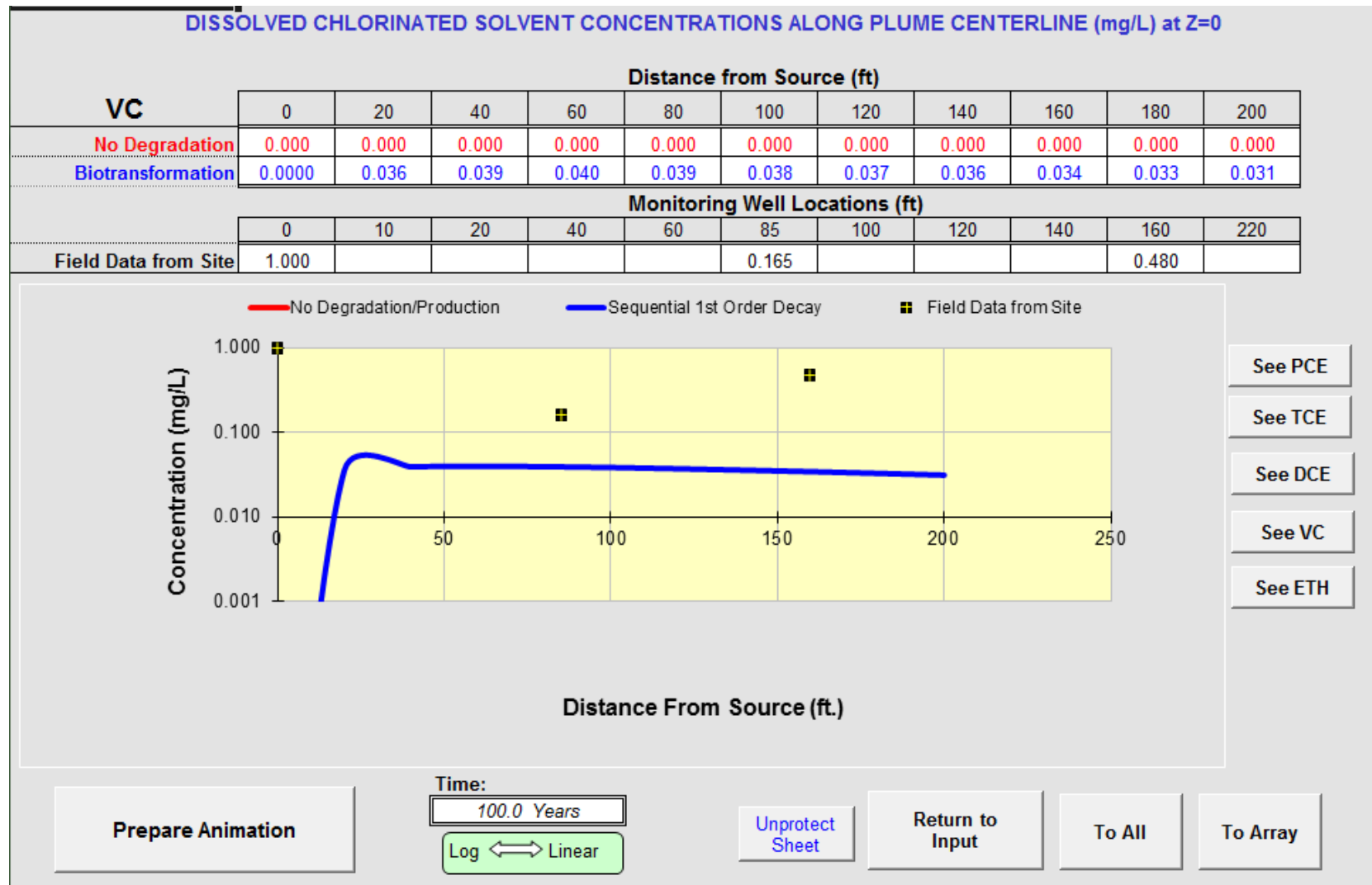
Unprotect
Sheet

Return to
Input

To All

To Array

Output screen for Baseline K BIOCHLOR VC with source concentrations taken from Table 2-9



Input screen for Baseline K BIOCHLOR Naphthalene model run with source concentration taken from Table 2-9

BIOCHLOR Natural Attenuation Decision Support System

Version 2.2

Excel 2000

CRS_SVOC

MW-14A to MW-11A

Run Name

Data Input Instructions:

- 115 → 1. Enter value directly....or
↑ or 2. Calculate by filling in gray
0.02 cells. Press Enter, then **C**
(To restore formulas, hit "Restore Formulas" button)
Variable* → Data used directly in model.

Test if
Biotransformation
is Occurring → Natural Attenuation
Screening Protocol

TYPE OF CHLORINATED SOLVENT:

Ethenes ☒

Ethanes ☐

5. GENERAL

Simulation Time*

100 (yr)

Modeled Area Width*

200 (ft)

Modeled Area Length*

200 (ft)

Zone 1 Length*

200 (ft)

Zone 2 Length*

0 (ft)

L

W

Zone 2=

L - Zone 1

6. SOURCE DATA

Source Options

TYPE: Continuous

Single Planar

Source Thickness in Sat. Zone* 5 (ft)

Width* (ft) 10

Conc. (mg/L)* C1

PCE 1.97

TCE

DCE

VC

ETH

k_s*

(1/yr)

0

0

0

0

0

View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)

7.405

TCE Conc. (mg/L)

.052

DCE Conc. (mg/L)

.011

VC Conc. (mg/L)

ETH Conc. (mg/L)

Distance from Source (ft)

0

10

20

40

60

85

100

120

140

160

220

Date Data Collected

2011

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN
CENTERLINE

RUN ARRAY

Help

Restore

RESET

SEE
OUTPUT

Paste

Unprotect

1. ADVECTION

Seepage Velocity*

Vs

172.2 (ft/yr)

or

Hydraulic Conductivity

K

5.3E-04 (cm/sec)

Hydraulic Gradient

i

0.0628 (ft/ft)

Effective Porosity

n

0.2 (-)

2. DISPERSION

Alpha x*

50 (ft)

Calc.
Alpha x

(Alpha y) / (Alpha x)*

0.1 (-)

(Alpha z) / (Alpha x)*

1.E-02 (-)

3. ADSORPTION

Retardation Factor*

R

or

Soil Bulk Density, rho

1 (kg/L)

Fraction Organic Carbon, f_{oc}

0.0E+0 (-)

Partition Coefficient

K_{oc}

PCE

426 (L/kg)

1.00 (-)

TCE

130 (L/kg)

1.00 (-)

DCE

125 (L/kg)

1.00 (-)

VC

30 (L/kg)

1.00 (-)

ETH

302 (L/kg)

1.00 (-)

Common R (used in model)* = 1.00

4. BIOTRANSFORMATION

-1st Order Decay Coefficient*

Zone 1

λ (1/yr)

half-life (yrs)

Yield

PCE → TCE

6.000

0.79

TCE → DCE

0.000

0.74

DCE → VC

0.000

0.64

VC → ETH

0.000

0.45

Zone 2

λ (1/yr)

half-life (yrs)

PCE → TCE

0.000

TCE → DCE

0.000

DCE → VC

0.000

VC → ETH

0.000

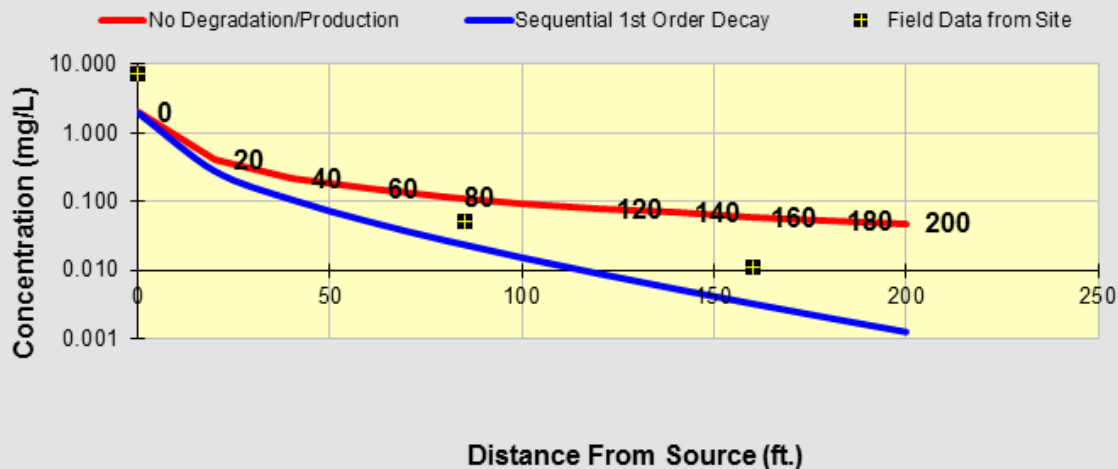
λ
HELP

Output screen for Baseline K BIOCHLOR Naphthalene with source concentrations taken from Table 2-9

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

PCE	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	1.970	0.401	0.222	0.153	0.117	0.095	0.080	0.069	0.060	0.054	0.048
Biotransformation	1.9700	0.278	0.107	0.051	0.027	0.015	0.009	0.005	0.003	0.002	0.001

Field Data from Site	Monitoring Well Locations (ft)										
	0	10	20	40	60	85	100	120	140	160	220
Field Data from Site	7.405					0.052				0.011	



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

100.0 Years

Log ↔ Linear

Unprotect Sheet

Return to Input

To All

To Array

Input screen for Baseline K BIOSCREEN

Benzene model run with source concentration taken from Table 2-9

BIOSCREEN Natural Attenuation Decision Support System
 Air Force Center for Environmental Excellence

Version 1.4
 CRS
 Benzene
 Run Name

Data Input Instructions:
 115
 or
 0.02
 Variable*
 20
 1. Enter value directly....or
 2. Calculate by filling in grey cells below. (To restore formulas, hit button below).
 Data used directly in model.
 Value calculated by model.
 (Don't enter any data).

1. HYDROGEOLOGY
 Seepage Velocity* Vs 172.2 (ft/yr)
 or
 Hydraulic Conductivity K 5.3E-04 (cm/sec)
 Hydraulic Gradient i 0.0628 (ft/ft)
 Porosity n 0.2 (-)

2. DISPERSION
 Longitudinal Dispersivity* alpha x 50.0 (ft)
 Transverse Dispersivity* alpha y 5.0 (ft)
 Vertical Dispersivity* alpha z 0.1 (ft)
 or
 Estimated Plume Length Lp 200 (ft)

3. ADSORPTION
 Retardation Factor* R 1.0 (-)
 or
 Soil Bulk Density rho 1.7 (kg/l)
 Partition Coefficient Koc 38 (L/kg)
 Fraction Organic Carbon foc 5.7E-5 (-)

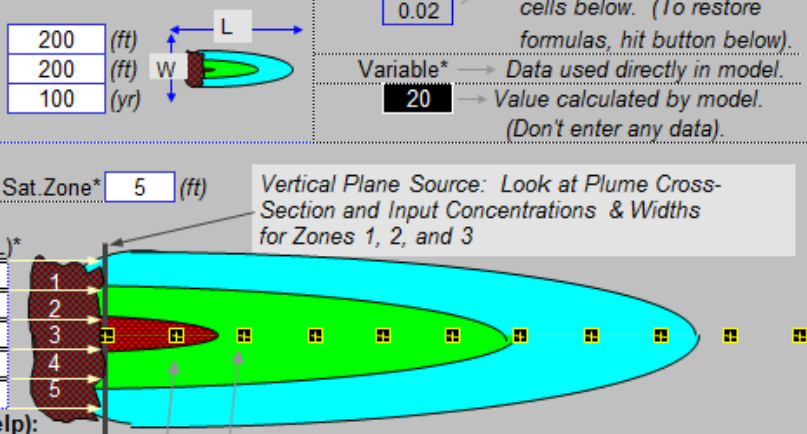
4. BIODEGRADATION
 1st Order Decay Coeff* lambda 5.6E-1 (per yr)
 or
 Solute Half-Life t-half (year)
 or Instantaneous Reaction Model
 Delta Oxygen* DO (mg/L)
 Delta Nitrate* NO3 (mg/L)
 Observed Ferrous Iron* Fe2+ (mg/L)
 Delta Sulfate* SO4 (mg/L)
 Observed Methane* CH4 (mg/L)

5. GENERAL
 Modeled Area Length* 200 (ft)
 Modeled Area Width* 200 (ft)
 Simulation Time* 100 (yr)

6. SOURCE DATA
 Source Thickness in Sat Zone* 5 (ft)
 Source Zones:

Width* (ft)	Conc. (mg/L)*
4	0.786
4	0.786
4	0.786
4	0.786
4	0.786

 Source Half-life (see Help):
 >1000 >1000 (yr)
 Inst React 1st Order
 Soluble Mass 46000 (Kg)
 In Source NAPL, Soil

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

 View of Plume Looking Down
 Observed Centerline Concentrations at Monitoring Wells
 If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	6.3				.84				.62		
Dist. from Source (ft)	0	20	40	60	85	100	120	140	160	180	200

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE
 View Output

RUN ARRAY
 View Output

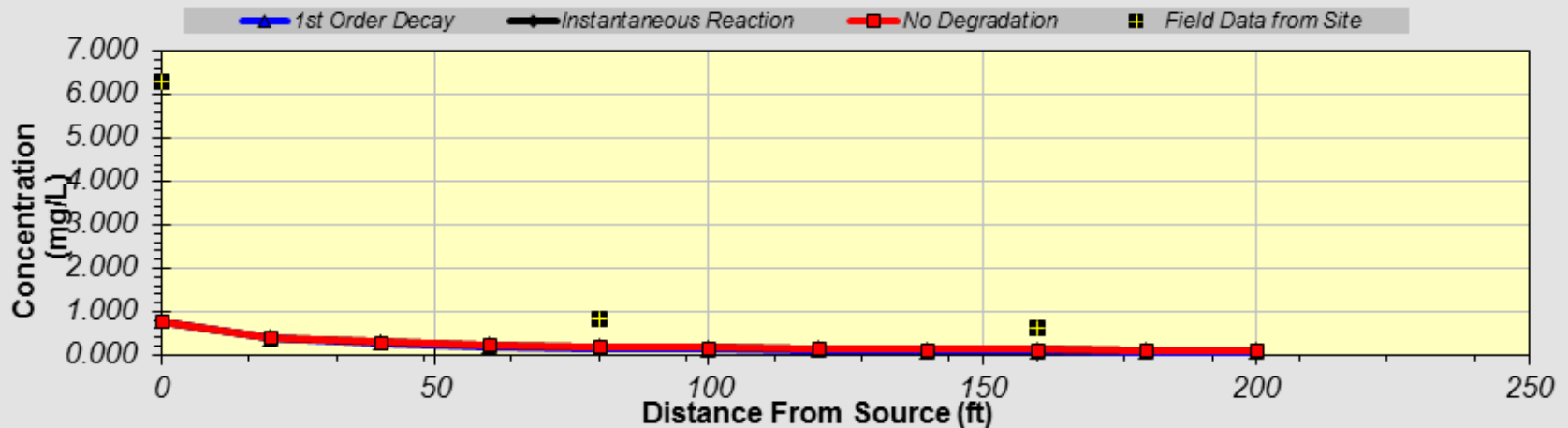
Help
 Recalculate
 Paste Example Dataset
 Restore Formulas for Vs,

Output screen for Baseline K BIOSCREEN

Benzene with source concentrations taken from Table 2-9

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	0.786	0.409	0.297	0.239	0.200	0.173	0.152	0.136	0.122	0.111	0.102
1st Order Decay	0.786	0.386	0.265	0.201	0.160	0.130	0.108	0.091	0.078	0.067	0.058
Inst. Reaction	0.786	0.409	0.297	0.239	0.200	0.173	0.152	0.136	0.122	0.111	0.102
Field Data from Site	6.300				0.840				0.620		



Calculate
Animation

Time:

100 Years

Return to
Input

Recalculate This

Input screen for Baseline K BIOSCREEN

Toluene model run with source concentration taken from Table 2-9

BIOSCREEN Natural Attenuation Decision Support System
Air Force Center for Environmental Excellence Version 1.4

CRS
Toluene
Run Name

1. HYDROGEOLOGY
Seepage Velocity* Vs 172.2 (ft/yr)
or
Hydraulic Conductivity K 5.3E-04 (cm/sec)
Hydraulic Gradient i 0.0628 (ft/ft)
Porosity n 0.2 (-)

2. DISPERSION
Longitudinal Dispersivity* alpha x 50.0 (ft)
Transverse Dispersivity* alpha y 5.0 (ft)
Vertical Dispersivity* alpha z 0.1 (ft)
or
Estimated Plume Length Lp 200 (ft)

3. ADSORPTION
Retardation Factor* R 1.0 (-)
or
Soil Bulk Density rho 1.7 (kg/l)
Partition Coefficient Koc 38 (L/kg)
Fraction Organic Carbon foc 5.7E-5 (-)

4. BIODEGRADATION
1st Order Decay Coeff* lambda 9.5E+0 (per yr)
or
Solute Half-Life t-half 0.08 (year)
or Instantaneous Reaction Model
Delta Oxygen* DO (mg/L)
Delta Nitrate* NO3 (mg/L)
Observed Ferrous Iron* Fe2+ (mg/L)
Delta Sulfate* SO4 (mg/L)
Observed Methane* CH4 (mg/L)

5. GENERAL
Modeled Area Length* 200 (ft)
Modeled Area Width* 200 (ft)
Simulation Time* 100 (yr)

6. SOURCE DATA
Source Thickness in Sat. Zone* 5 (ft)
Source Zones:
Width* (ft) Conc. (mg/L)*
4 7.39
4 7.39
4 7.39
4 7.39
4 7.39
Source Half-life (see Help):
>1000 >1000 (yr)
Inst. React. 1st Order
Soluble Mass 46000 (Kg)
In Source NAPL, Soil

7. FIELD DATA FOR COMPARISON
Concentration (mg/L) 40.0 .68 .12
Dist. from Source (ft) 0 20 40 60 85 100 120 140 160 180 200

8. CHOOSE TYPE OF OUTPUT TO SEE:
RUN CENTERLIN View Output
RUN ARRAY View Output
Help Recalculate
Paste Example Dataset
Restore Formulas for Vs,

Data Input Instructions:
115 1. Enter value directly....or
or 2. Calculate by filling in grey
0.02 cells below. (To restore
formulas, hit button below).
Variable* Data used directly in model.
20 Value calculated by model.
(Don't enter any data).

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

View of Plume Looking Down

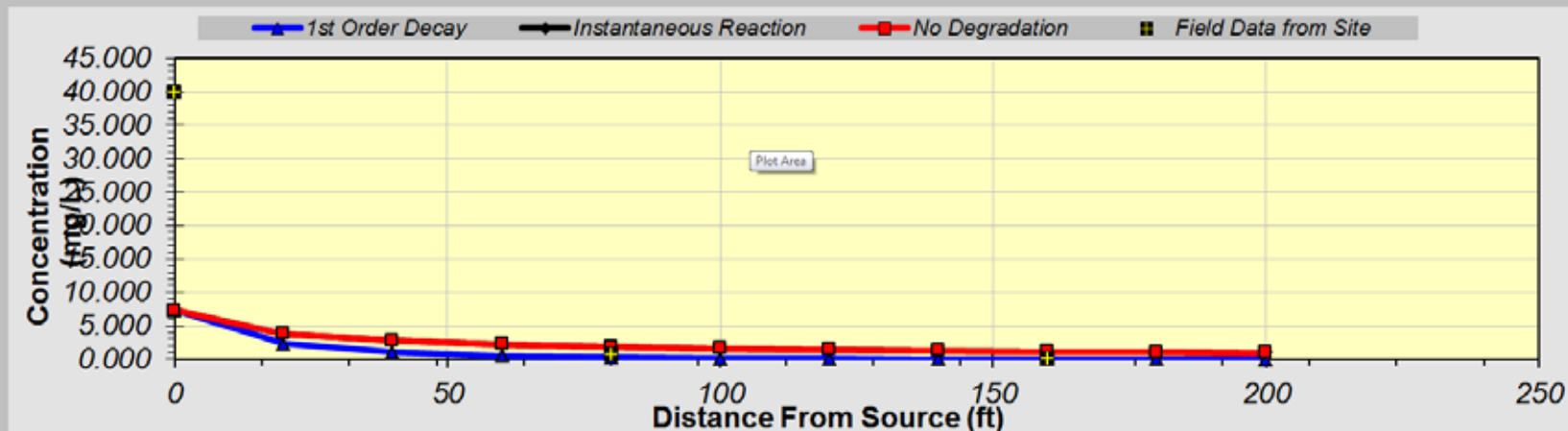
Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

Output screen for Baseline K BIOSCREEN

Toluene with source concentrations taken from Table 2-9

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	7.378	3.839	2.790	2.242	1.882	1.623	1.427	1.273	1.149	1.047	0.961
1st Order Decay	7.378	2.343	1.039	0.510	0.261	0.137	0.074	0.040	0.022	0.012	0.007
Inst. Reaction	7.378	3.839	2.790	2.242	1.882	1.623	1.427	1.273	1.149	1.047	0.961
Field Data from Site	40.000				0.680				0.120		



Calculate
Animation

Time:
100 Years

Return to

Recalculate This

Input screen for Baseline K BIOSCREEN

Ethylbenzene model run with source concentration taken from Table 2-9

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence

Version 1.4

CRS

Ethylbenzene

Run Name

Data Input Instructions:

115

↑ or

0.02

1. Enter value directly...or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* → Data used directly in model.

20 → Value calculated by model.

(Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity* Vs 172.2 (ft/yr)
↑ or
Hydraulic Conductivity K 5.3E-04 (cm/sec)
Hydraulic Gradient i 0.0628 (ft/ft)
Porosity n 0.2 (-)

2. DISPERSION

Longitudinal Dispersivity* alpha x 50.0 (ft)
Transverse Dispersivity* alpha y 5.0 (ft)
Vertical Dispersivity* alpha z 0.1 (ft)
↑ or
Estimated Plume Length Lp 200 (ft)

3. ADSORPTION

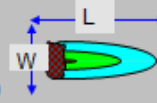
Retardation Factor* R 1.0 (-)
↑ or
Soil Bulk Density rho 1.7 (kg/l)
Partition Coefficient Koc 38 (L/kg)
Fraction Organic Carbon foc 5.7E-5 (-)

4. BIODEGRADATION

1st Order Decay Coeff* lambda 9.0E-1 (per yr)
↑ or
Solute Half-Life t-half 0.08 (year)
or Instantaneous Reaction Model
Delta Oxygen* DO (mg/L)
Delta Nitrate* NO3 (mg/L)
Observed Ferrous Iron* Fe2+ (mg/L)
Delta Sulfate* SO4 (mg/L)
Observed Methane* CH4 (mg/L)

5. GENERAL

Modeled Area Length* 200 (ft)
Modeled Area Width* 200 (ft)
Simulation Time* 100 (yr)



6. SOURCE DATA

Source Thickness in Sat.Zone* 5 (ft)

Source Zones:

Width* (ft)	Conc. (mg/L)*
4	0.433
4	0.433
4	0.433
4	0.433
4	0.433

Source Half-life (see Help):

>1000 >1000 (yr)

Inst. React. ↑ 1st Order

Soluble Mass 46000 (Kg)

In Source NAPL, Soil

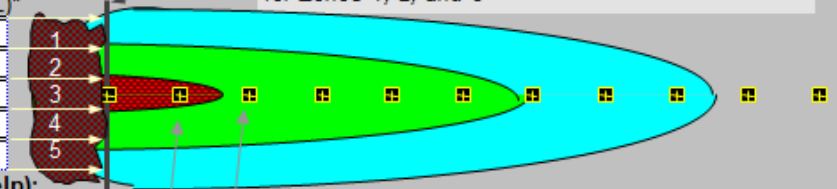
7. FIELD DATA FOR COMPARISON

Concentration (mg/L)

Dist. from Source (ft)

1.1				.46				.086		
0	20	40	60	85	100	120	140	160	180	200

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN
CENTERLINE

RUN ARRAY

View Output

View Output

Help

Recalculate
This Sheet

Paste Example Dataset

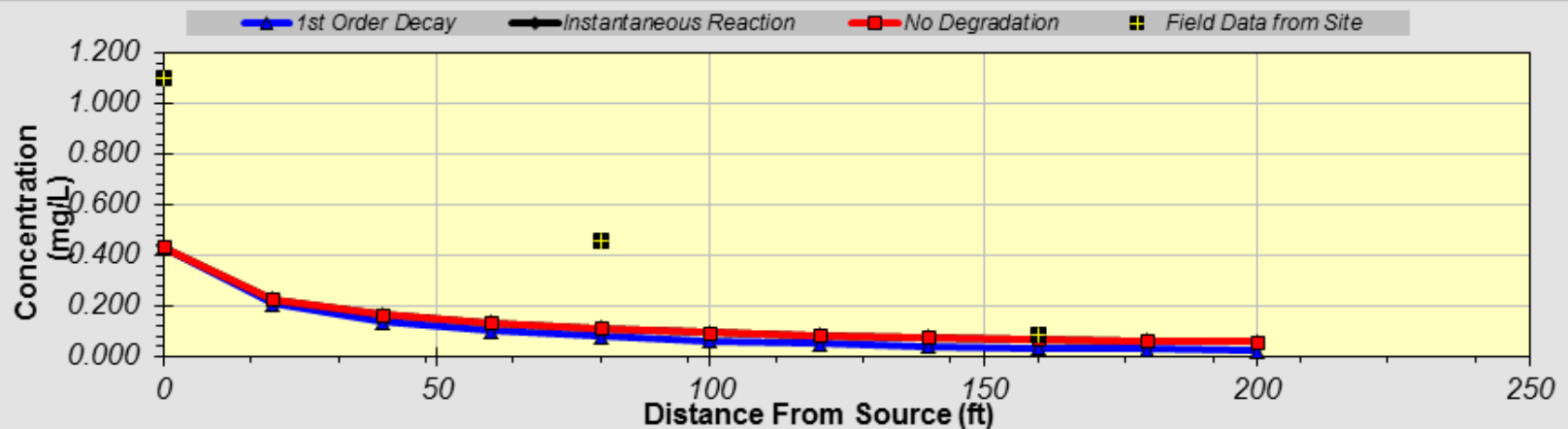
Restore Formulas for Vs,
Dispersivities, R, lambda, other

Output screen for Baseline K BIOSCREEN

Ethylbenzene run with source concentrations taken from Table 2-9

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	0.433	0.225	0.164	0.132	0.110	0.095	0.084	0.075	0.067	0.061	0.056
1st Order Decay	0.433	0.207	0.138	0.102	0.078	0.062	0.050	0.041	0.034	0.028	0.024
Inst. Reaction	0.433	0.225	0.164	0.132	0.110	0.095	0.084	0.075	0.067	0.061	0.056
Field Data from Site	1.100				0.460				0.086		



Calculate
Animation

Time:

100 Years

Return to
Input

Recalculate This
Sheet

Input screen for Baseline K BIOSCREEN

Total Xylenes model run with source concentration taken from Table 2-9

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence

Version 1.4

CRS
Total Xylenes
Run Name

1. HYDROGEOLOGY

Seepage Velocity* Vs 172.2 (ft/yr)
or
Hydraulic Conductivity K 5.3E-04 (cm/sec)
Hydraulic Gradient i 0.0628 (ft/ft)
Porosity n 0.2 (-)

2. DISPERSION

Longitudinal Dispersivity* alpha x 50.0 (ft)
Transverse Dispersivity* alpha y 5.0 (ft)
Vertical Dispersivity* alpha z 0.1 (ft)
or
Estimated Plume Length Lp 200 (ft)

3. ADSORPTION

Retardation Factor* R 1.0 (-)
or
Soil Bulk Density rho 1.7 (kg/l)
Partition Coefficient Koc 38 (L/kg)
Fraction Organic Carbon foc 5.7E-5 (-)

4. BIODEGRADATION

1st Order Decay Coeff* lambda 2.2E+0 (per yr)
or
Solute Half-Life t-half 0.08 (year)
or Instantaneous Reaction Model

Delta Oxygen* DO (mg/L)
Delta Nitrate* NO3 (mg/L)
Observed Ferrous Iron* Fe2+ (mg/L)
Delta Sulfate* SO4 (mg/L)
Observed Methane* CH4 (mg/L)

5. GENERAL

Modeled Area Length* 200 (ft)
Modeled Area Width* 200 (ft)
Simulation Time* 100 (yr)

6. SOURCE DATA

Source Thickness in Sat Zone* 5 (ft)
Source Zones:

Width* (ft)	Conc. (mg/L)*
4	2.12
4	2.12
4	2.12
4	2.12
4	2.12

Source Halflife (see Help):
>1000 >1000 (yr)
Inst. React. 1st Order
Soluble Mass 46000 (Kg)
In Source NAPL, Soil

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	4.8				1.3				.18		
Dist. from Source (ft)	0	20	40	60	85	100	120	140	160	180	200

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

View Output

RUN ARRAY

View Output

Help

Recalculate This Sheet

Paste Example Dataset

Restore Formulas for Vs, Dispersivities, R, lambda, other

Data Input Instructions:

115 or 0.02
Variable* 20
1. Enter value directly...or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below)
Data used directly in model.
Value calculated by model. (Don't enter any data).

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

View of Plume Looking Down

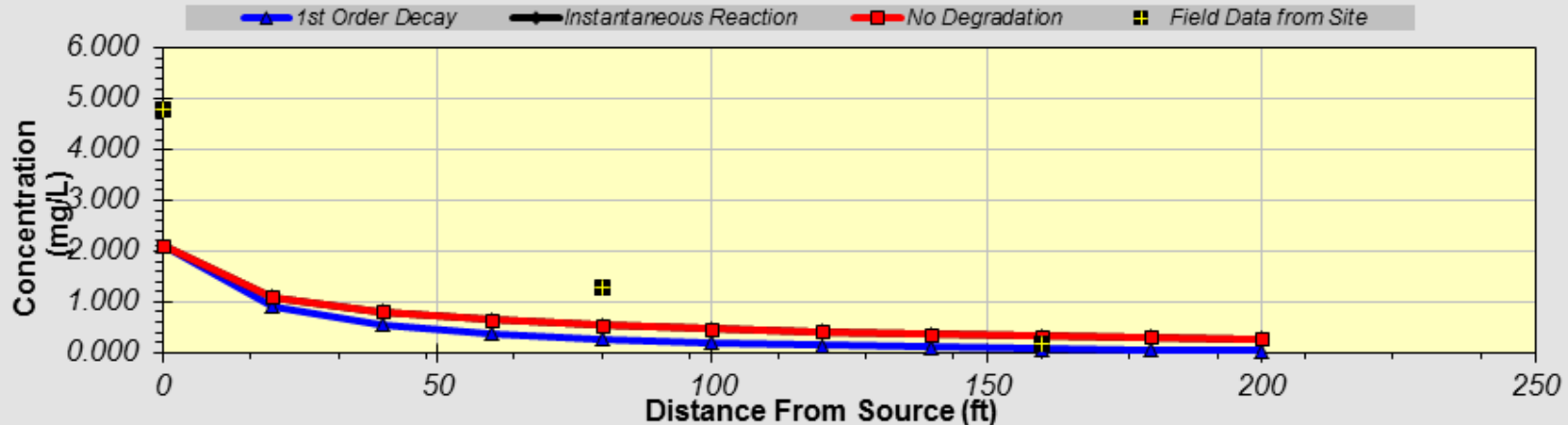
Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

Output screen for Baseline K BIOSCREEN

Total Xylenes with source concentrations taken from Table 2-9

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	2.119	1.103	0.801	0.644	0.540	0.466	0.410	0.366	0.330	0.301	0.276
1st Order Decay	2.119	0.924	0.562	0.378	0.266	0.192	0.142	0.106	0.080	0.061	0.047
Inst. Reaction	2.119	1.103	0.801	0.644	0.540	0.466	0.410	0.366	0.330	0.301	0.276
Field Data from Site	4.800				1.300				0.180		



Calculate Animation

Time:

100 Years

Return to Input

Recalculate This Sheet



BIOCHLOR / BIOSCREEN Low K Simulations

LNAST FRACTURE FLOW

Input screen for Low K BIOCHLOR TCE, DCE, and VC model runs with source concentrations taken from Table 2-9

BIOCHLOR Natural Attenuation Decision Support System

Version 2.2
Excel 2000

TYPE OF CHLORINATED SOLVENT: Ethenes ☒ Ethanes ☐

1. ADVECTION

Seepage Velocity* Vs (ft/yr) C

Hydraulic Conductivity K (cm/sec)

Hydraulic Gradient i (ft/ft)

Effective Porosity n (-)

2. DISPERSION

Alpha x* (ft) Calc. Alpha x

(Alpha y) / (Alpha x)* (-)

(Alpha z) / (Alpha x)* (-)

3. ADSORPTION

Retardation Factor* C

Soil Bulk Density, rho (kg/L)

Fraction Organic Carbon, f_{oc} (-)

Partition Coefficient K_{oc}

PCE	426 (L/kg)	<input type="text" value="1.00"/> (-)
TCE	130 (L/kg)	<input type="text" value="1.00"/> (-)
DCE	125 (L/kg)	<input type="text" value="1.00"/> (-)
VC	30 (L/kg)	<input type="text" value="1.00"/> (-)
ETH	302 (L/kg)	<input type="text" value="1.00"/> (-)

Common R (used in model)* = C

4. BIOTRANSFORMATION

Zone 1

λ (1/yr)	half-life (yrs)	Yield
PCE → TCE: 0.000	<input type="text"/>	0.79
TCE → DCE: 7.000	<input type="text"/>	0.74
DCE → VC: 0.700	<input type="text"/>	0.64
VC → ETH: 0.500	<input type="text"/>	0.45

Zone 2

λ (1/yr)	half-life (yrs)
PCE → TCE: 0.000	<input type="text"/>
TCE → DCE: 0.000	<input type="text"/>
DCE → VC: 0.000	<input type="text"/>
VC → ETH: 0.000	<input type="text"/>

λ HELP

5. GENERAL

Simulation Time* (yr)

Modeled Area Width* (ft)

Modeled Area Length* (ft)

Zone 1 Length* (ft)

Zone 2 Length* (ft)

Zone 2 = L - Zone 1

6. SOURCE DATA

Source Options TYPE: Continuous Single Planar

Source Thickness in Sat. Zone* (ft)

Width* (ft) Y1

Conc. (mg/L)* C1

PCE	<input type="text" value="0"/>
TCE	<input type="text" value="4.12"/>
DCE	<input type="text" value="2.98"/>
VC	<input type="text" value="0"/>
ETH	<input type="text" value="0"/>

k_s^* (1/yr)

PCE	<input type="text" value="0"/>
TCE	<input type="text" value="0"/>
DCE	<input type="text" value="0"/>
VC	<input type="text" value="0"/>
ETH	<input type="text" value="0"/>

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)	<input type="text" value="1.0"/>	<input type="text" value="0.165"/>	<input type="text" value="0.032"/>
TCE Conc. (mg/L)	<input type="text" value="16.0"/>	<input type="text" value="0.165"/>	<input type="text" value="0.019"/>
DCE Conc. (mg/L)	<input type="text" value="50.0"/>	<input type="text" value="8.2"/>	<input type="text" value="0.96"/>
VC Conc. (mg/L)	<input type="text" value="1.0"/>	<input type="text" value="0.165"/>	<input type="text" value="0.48"/>
ETH Conc. (mg/L)	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>

Distance from Source (ft)

<input type="text" value="0"/>	<input type="text" value="10"/>	<input type="text" value="20"/>	<input type="text" value="40"/>	<input type="text" value="60"/>	<input type="text" value="85"/>	<input type="text" value="100"/>	<input type="text" value="120"/>	<input type="text" value="140"/>	<input type="text" value="160"/>	<input type="text" value="220"/>
--------------------------------	---------------------------------	---------------------------------	---------------------------------	---------------------------------	---------------------------------	----------------------------------	----------------------------------	----------------------------------	----------------------------------	----------------------------------

Date Data Collected

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

RUN ARRAY

Help

Restore

RESET

SEE OUTPUT

Paste

Unprotect

Data Input Instructions:

→ 1. Enter value directly....or

↑ or → 2. Calculate by filling in gray cells. Press Enter, then **C**

(To restore formulas, hit "Restore Formulas" button)

Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations

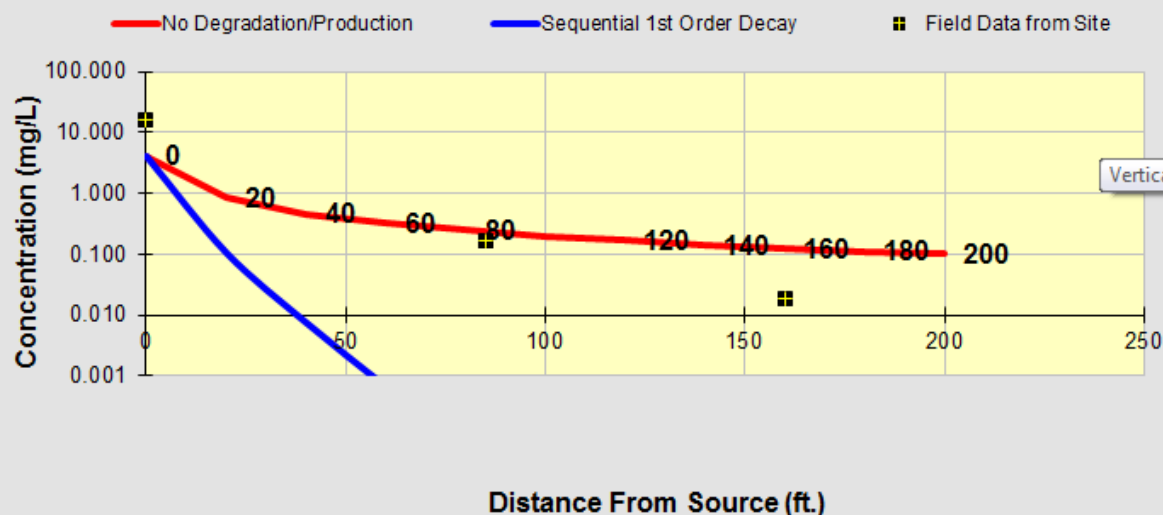
View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

Output screen for Low K BIOCHLOR TCE model with source concentrations taken from Table 2-9

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

TCE	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	4.120	0.838	0.464	0.321	0.245	0.198	0.166	0.143	0.126	0.112	0.101
Biotransformation	4.1200	0.107	0.008	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site	Monitoring Well Locations (ft)										
	0	10	20	40	60	85	100	120	140	160	220
	16.000					0.165				0.019	



See PCE

See TCE

Vertical (Value) Axis Major Gridlines

See DCE

See VC

See ETH

Prepare Animation

Time:

100.0 Years

Log ↔ Linear

Unprotect Sheet

Return to Input

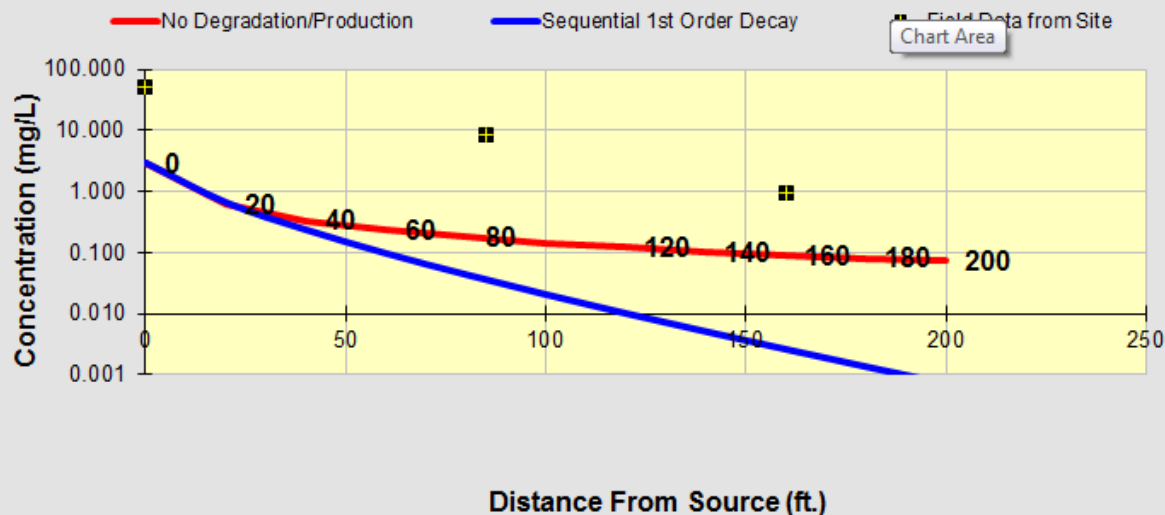
To All

To Array

Output screen for Low K BIOCHLOR DCE model with source concentrations taken from Table 2-9

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

DCE	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	2.980	0.606	0.336	0.232	0.177	0.143	0.120	0.104	0.091	0.081	0.073
Biotransformation	2.9800	0.667	0.237	0.098	0.044	0.021	0.010	0.005	0.003	0.001	0.001
	Monitoring Well Locations (ft)										
	0	10	20	40	60	85	100	120	140	160	220
Field Data from Site	50.000					8.200				0.960	



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

100.0 Years

Log ↔ Linear

Unprotect Sheet

Return to Input

To All

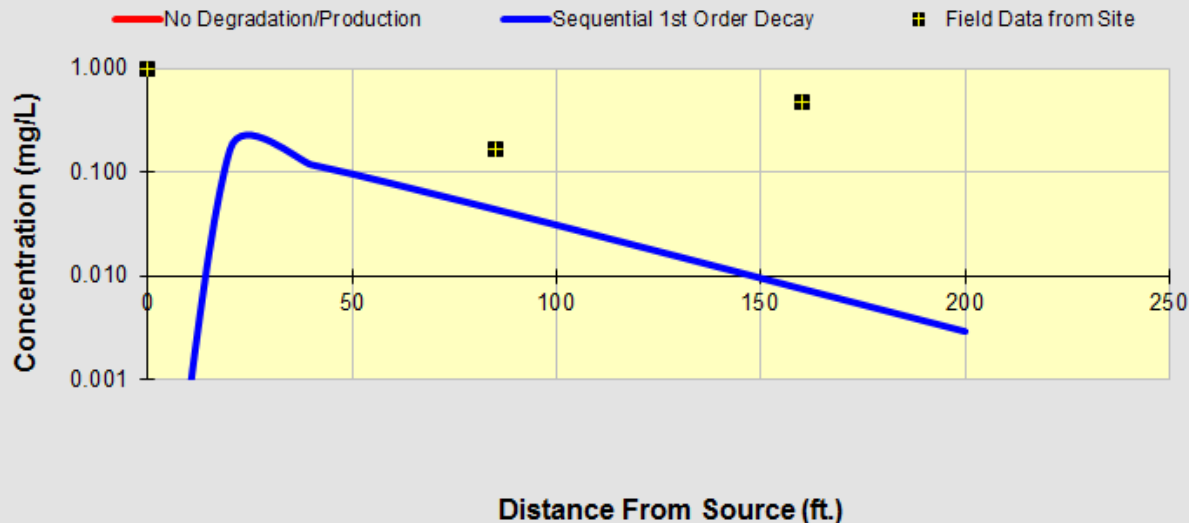
To Array

Output screen for Low K BIOCHLOR VC model with source concentrations taken from Table 2-9

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

VC	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biotransformation	0.0000	0.164	0.118	0.077	0.049	0.031	0.019	0.012	0.008	0.005	0.003

Field Data from Site	Monitoring Well Locations (ft)										
	0	10	20	40	60	85	100	120	140	160	220
Field Data from Site	1.000					0.165				0.480	



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

100.0 Years

Log ↔ Linear

Unprotect
Sheet

Return to
Input

To All

To Array

Input screen for Low K BIOCHLOR

Naphthalene model run with source concentration taken from Table 2-9

BIOCHLOR Natural Attenuation Decision Support System

Version 2.2
Excel 2000

TYPE OF CHLORINATED SOLVENT: Ethenes ☒ Ethanes ☐

1. ADVECTION

Seepage Velocity* Vs (ft/yr) C

Hydraulic Conductivity K (cm/sec)

Hydraulic Gradient i (ft/ft)

Effective Porosity n (-)

2. DISPERSION

Alpha x* (ft)

(Alpha y) / (Alpha x)* (-)

(Alpha z) / (Alpha x)* (-)

3. ADSORPTION

Retardation Factor* C

Soil Bulk Density, rho (kg/L)

Fraction Organic Carbon, foc (-)

Partition Coefficient Koc

PCE	426	(L/kg)	<input type="text" value="1.00"/> (-)
TCE	130	(L/kg)	<input type="text" value="1.00"/> (-)
DCE	125	(L/kg)	<input type="text" value="1.00"/> (-)
VC	30	(L/kg)	<input type="text" value="1.00"/> (-)
ETH	302	(L/kg)	<input type="text" value="1.00"/> (-)

Common R (used in model)* = C

4. BIOTRANSFORMATION

Zone 1

Process	λ (1/yr)	half-life (yrs)	Yield
PCE → TCE	<input type="text" value="6.000"/>	<input type="text"/>	0.79
TCE → DCE	<input type="text" value="0.000"/>	<input type="text"/>	0.74
DCE → VC	<input type="text" value="0.000"/>	<input type="text"/>	0.64
VC → ETH	<input type="text" value="0.000"/>	<input type="text"/>	0.45

Zone 2

Process	λ (1/yr)	half-life (yrs)
PCE → TCE	<input type="text" value="0.000"/>	<input type="text"/>
TCE → DCE	<input type="text" value="0.000"/>	<input type="text"/>
DCE → VC	<input type="text" value="0.000"/>	<input type="text"/>
VC → ETH	<input type="text" value="0.000"/>	<input type="text"/>

λ HELP

5. GENERAL

Simulation Time* (yr)

Modeled Area Width* (ft)

Modeled Area Length* (ft)

Zone 1 Length* (ft)

Zone 2 Length* (ft)

Zone 2 = L - Zone 1

6. SOURCE DATA

Source Options

Source Thickness in Sat. Zone* (ft)

Width* (ft)

Conc. (mg/L)* C1

PCE	<input type="text" value="1.97"/>
TCE	<input type="text"/>
DCE	<input type="text"/>
VC	<input type="text"/>
ETH	<input type="text"/>

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)	7.405					.052				.011	
TCE Conc. (mg/L)											
DCE Conc. (mg/L)											
VC Conc. (mg/L)											
ETH Conc. (mg/L)											
Distance from Source (ft)	0	10	20	40	60	85	100	120	140	160	220
Date Data Collected	2011										

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

RUN ARRAY

Help

Restore

RESET

SEE OUTPUT

Paste

Unprotect

Data Input Instructions:

115 → 1. Enter value directly....or
↑ or 0.02 → 2. Calculate by filling in gray cells. Press Enter, then **C**

(To restore formulas, hit "Restore Formulas" button)

Variable* → Data used directly in model.

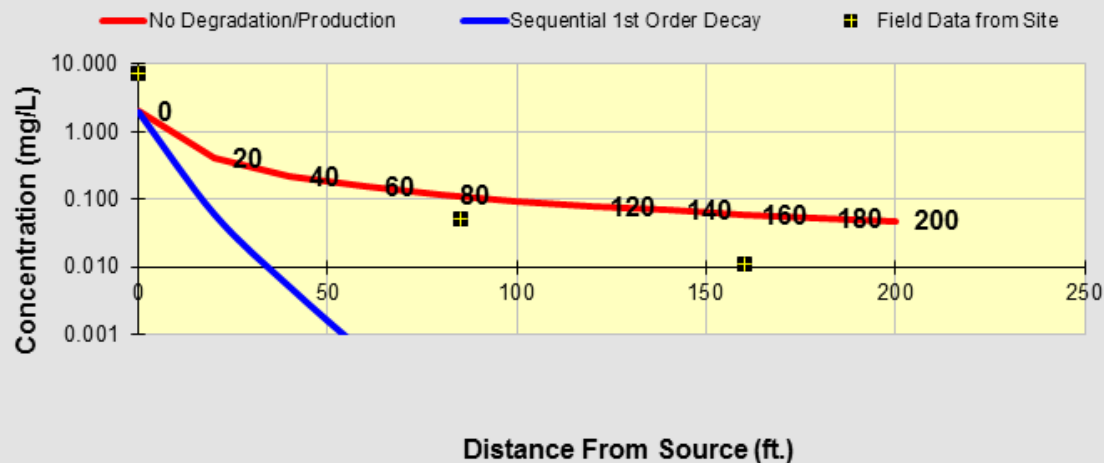
Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

Output screen for Low K BIOCHLOR Naphthalene model with source concentrations taken from Table 2-9

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

PCE	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	1.970	0.401	0.222	0.153	0.117	0.095	0.080	0.069	0.060	0.054	0.048
Biotransformation	1.9700	0.060	0.005	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Field Data from Site	Monitoring Well Locations (ft)										
	0	10	20	40	60	85	100	120	140	160	220
Field Data from Site	7.405					0.052				0.011	



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

100.0 Years

Log ↔ Linear

Unprotect
Sheet

Return to
Input

To All

To Array

1e

Input screen for Low K BIOCHLOR Benzene model run with source concentration taken from Table 2-9

BIOSCREEN Natural Attenuation Decision Support System
Air Force Center for Environmental Excellence

Version 1.4

CRS
Benzene
Run Name

Data Input Instructions:

115 or 0.02
Variable* → Data used directly in model.
20 → Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity* Vs 11.1 (ft/yr)
or
Hydraulic Conductivity K 3.4E-05 (cm/sec)
Hydraulic Gradient i 0.0628 (ft/ft)
Porosity n 0.2 (-)

2. DISPERSION

Longitudinal Dispersivity* alpha x 50.0 (ft)
Transverse Dispersivity* alpha y 5.0 (ft)
Vertical Dispersivity* alpha z 0.1 (ft)
or
Estimated Plume Length Lp 200 (ft)

3. ADSORPTION

Retardation Factor* R 1.0 (-)
or
Soil Bulk Density rho 1.7 (kg/l)
Partition Coefficient Koc 38 (L/kg)
Fraction Organic Carbon foc 5.7E-5 (-)

4. BIODEGRADATION

1st Order Decay Coeff* lambda 5.6E-1 (per yr)
or
Solute Half-Life t-half (year)
or Instantaneous Reaction Model

Delta Oxygen* DO (mg/L)
Delta Nitrate* NO3 (mg/L)
Observed Ferrous Iron* Fe2+ (mg/L)
Delta Sulfate* SO4 (mg/L)
Observed Methane* CH4 (mg/L)

5. GENERAL

Modeled Area Length* 200 (ft)
Modeled Area Width* 200 (ft)
Simulation Time* 100 (yr)

6. SOURCE DATA

Source Thickness in Sat Zone* 5 (ft)
Source Zones:

Width* (ft)	Conc. (mg/L)*
4	0.786
4	0.786
4	0.786
4	0.786
4	0.786

Source Half-life (see Help):
>1000 >1000 (yr)
Inst React 1st Order
Soluble Mass 46000 (Kg)
In Source NAPL, Soil

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	6.3				.84			.62			
Dist. from Source (ft)	0	20	40	60	85	100	120	140	160	180	200

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE **RUN ARRAY**

View Output **View Output**

Help Recalculate This Sheet

Paste Example Dataset

Restore Formulas for Vs, Dispersivities, R, lambda, other

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

View of Plume Looking Down

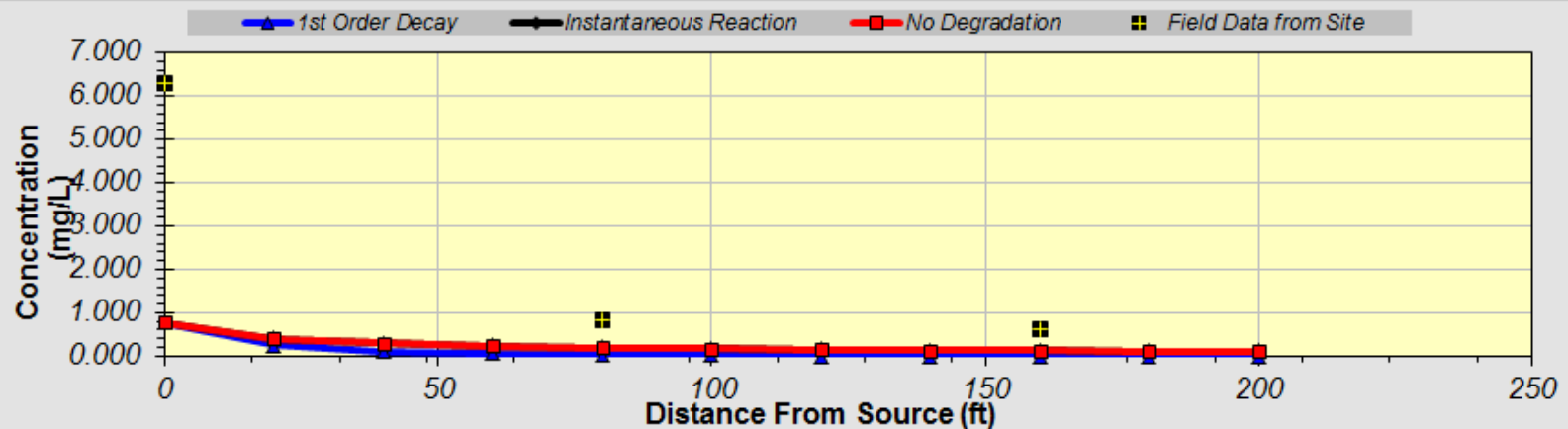
Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

Output screen for Low K BIOSCREEN

Benzene model with source concentrations taken from Table 2-9

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	0.786	0.409	0.297	0.239	0.200	0.173	0.152	0.135	0.122	0.111	0.102
1st Order Decay	0.786	0.257	0.117	0.059	0.031	0.017	0.009	0.005	0.003	0.002	0.001
Inst. Reaction	0.786	0.409	0.297	0.239	0.200	0.173	0.152	0.135	0.122	0.111	0.102
Field Data from Site	6.300				0.840				0.620		



Calculate
Animation

Time:

100 Years

Return to
Input

Recalculate This

Input screen for Low K BIOSCREEN

Toluene model run with source concentration taken from Table 2-9

BIOSCREEN Natural Attenuation Decision Support System
Air Force Center for Environmental Excellence

Version 1.4

CRS
Toluene
Run Name

1. HYDROGEOLOGY

Seepage Velocity* Vs 11.1 (ft/yr)
or
Hydraulic Conductivity K 3.4E-05 (cm/sec)
Hydraulic Gradient i 0.0628 (ft/ft)
Porosity n 0.2 (-)

2. DISPERSION

Longitudinal Dispersivity* alpha x 50.0 (ft)
Transverse Dispersivity* alpha y 5.0 (ft)
Vertical Dispersivity* alpha z 0.1 (ft)
or
Estimated Plume Length Lp 200 (ft)

3. ADSORPTION

Retardation Factor* R 1.0 (-)
or
Soil Bulk Density rho 1.7 (kg/l)
Partition Coefficient Koc 38 (L/kg)
Fraction Organic Carbon foc 5.7E-5 (-)

4. BIODEGRADATION

1st Order Decay Coeff* lambda 9.5E+0 (per yr)
or
Solute Half-Life t-half 0.08 (year)
or **Instantaneous Reaction Model**

Delta Oxygen* DO (mg/L)
Delta Nitrate* NO3 (mg/L)
Observed Ferrous Iron* Fe2+ (mg/L)
Delta Sulfate* SO4 (mg/L)
Observed Methane* CH4 (mg/L)

5. GENERAL

Modeled Area Length* 200 (ft)
Modeled Area Width* 200 (ft)
Simulation Time* 100 (yr)

6. SOURCE DATA

Source Thickness in Sat Zone* 5 (ft)
Source Zones:

Width* (ft)	Conc. (mg/L)*
4	7.39
4	7.39
4	7.39
4	7.39
4	7.39

Source Half-life (see Help):
>1000 >1000 (yr)
Inst. React 1st Order
Soluble Mass 46000 (Kg)
In Source NAPL, Soil

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	40.0				.68				.12		
Dist. from Source (ft)	0	20	40	60	85	100	120	140	160	180	200

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE **RUN ARRAY**

View Output **View Output**

Help Recalculate

Paste Example Dataset

Restore Formulas for Vs,

Data Input Instructions:

115 → 1. Enter value directly....or
↑ or 0.02 → 2. Calculate by filling in grey cells below. (To restore formulas, hit button below).
Variable* → Data used directly in model.
20 → Value calculated by model. (Don't enter any data).

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

View of Plume Looking Down

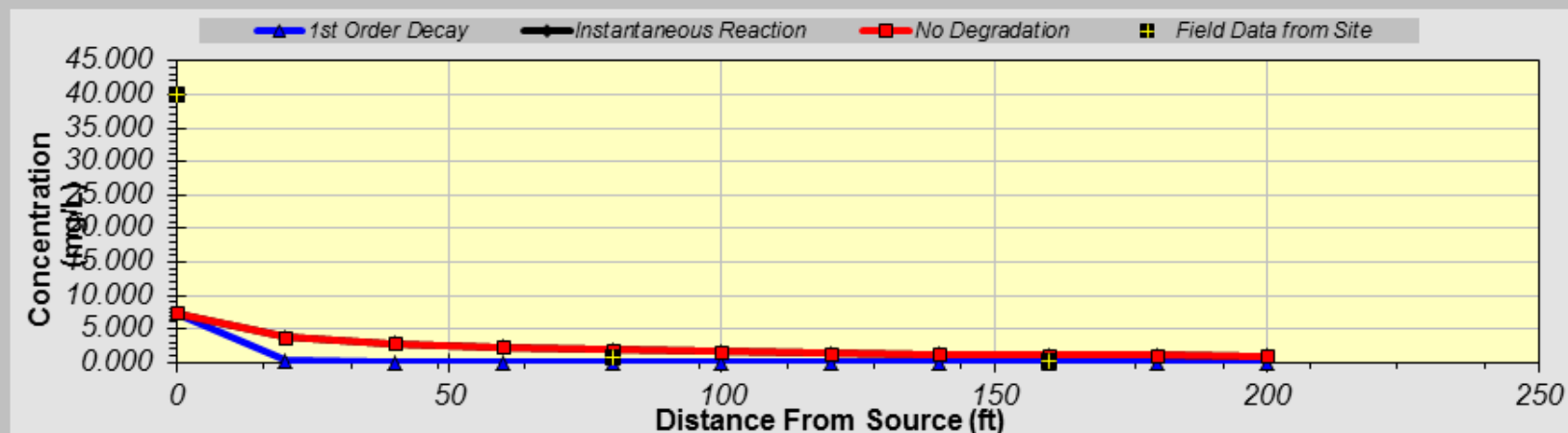
Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

Output screen for Low K BIOSCREEN

Toluene model with source concentrations taken from Table 2-9

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	7.389	3.842	2.793	2.243	1.883	1.623	1.427	1.272	1.148	1.046	0.960
1st Order Decay	7.389	0.340	0.022	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Inst. Reaction	7.389	3.842	2.793	2.243	1.883	1.623	1.427	1.272	1.148	1.046	0.960
Field Data from Site	40.000				0.680				0.120		



Calculate
Animation

Time:

100 Years

Return to
Input

Recalculate This
Sheet

Input screen for Low K BIOSCREEN

Ethylbenzene model run with source concentration taken from Table 2-9

BIOSCREEN Natural Attenuation Decision Support System
Air Force Center for Environmental Excellence

Version 1.4

CRS
Ethylbenzene
Run Name

1. HYDROGEOLOGY
Seepage Velocity* Vs 11.1 (ft/yr)
or
Hydraulic Conductivity K 3.4E-05 (cm/sec)
Hydraulic Gradient i 0.0628 (ft/ft)
Porosity n 0.2 (-)

2. DISPERSION
Longitudinal Dispersivity* alpha x 50.0 (ft)
Transverse Dispersivity* alpha y 5.0 (ft)
Vertical Dispersivity* alpha z 0.1 (ft)
or
Estimated Plume Length Lp 200 (ft)

3. ADSORPTION
Retardation Factor* R 1.0 (-)
or
Soil Bulk Density rho 1.7 (kg/l)
Partition Coefficient Koc 38 (L/kg)
Fraction Organic Carbon foc 5.7E-5 (-)

4. BIODEGRADATION
1st Order Decay Coeff* lambda 9.0E-1 (per yr)
or
Solute Half-Life t-half 0.08 (year)
or **Instantaneous Reaction Model**
Delta Oxygen* DO (mg/L)
Delta Nitrate* NO3 (mg/L)
Observed Ferrous Iron* Fe2+ (mg/L)
Delta Sulfate* SO4 (mg/L)
Observed Methane* CH4 (mg/L)

5. GENERAL
Modeled Area Length* 200 (ft)
Modeled Area Width* 200 (ft)
Simulation Time* 100 (yr)

6. SOURCE DATA
Source Thickness in Sat Zone* 5 (ft)
Source Zones:
Width* (ft) Conc. (mg/L)*
4 0.433
4 0.433
4 0.433
4 0.433
4 0.433
Source Half-life (see Help):
>1000 >1000 (yr)
Inst. React. 1st Order
Soluble Mass 46000 (Kg)
In Source NAPL Soil

7. FIELD DATA FOR COMPARISON
Concentration (mg/L) 1.1 .46 .086
Dist. from Source (ft) 0 20 40 60 85 100 120 140 160 180 200

8. CHOOSE TYPE OF OUTPUT TO SEE:
RUN CENTERLINE View Output
RUN ARRAY View Output
Help Recalculate This Sheet
Paste Example Dataset
Restore Formulas for Vs, Dispersivities, R, lambda, other

Data Input Instructions:
115 or 0.02
1. Enter value directly...or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).
Variable* Data used directly in model.
20 Value calculated by model. (Don't enter any data).

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

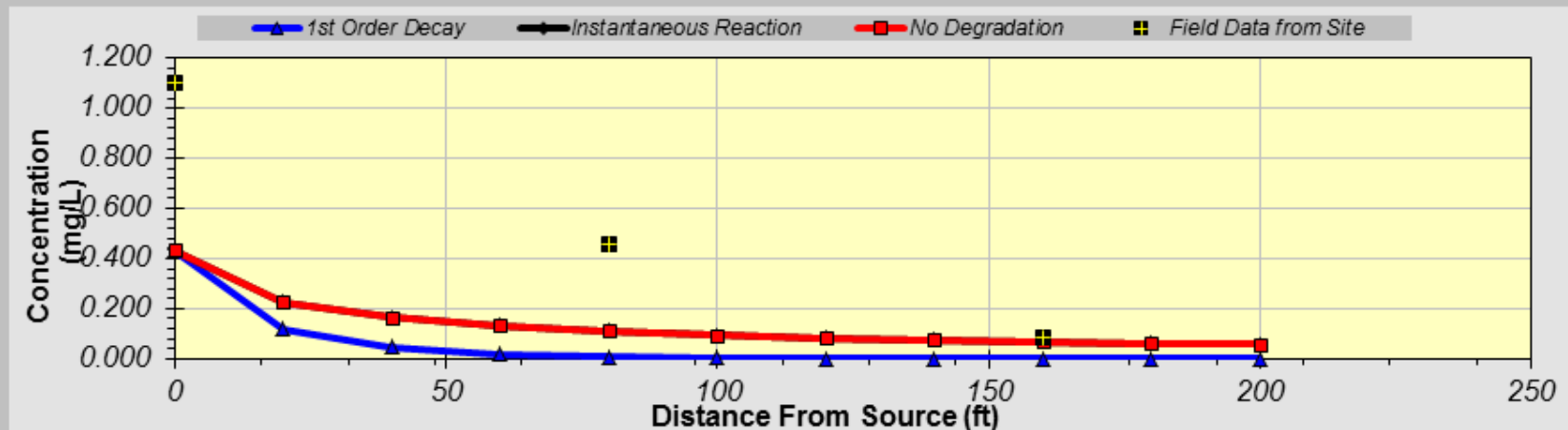
View of Plume Looking Down
Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

Output screen for Low K BIOSCREEN

Ethylbenzene model with source concentrations taken from Table 2-9

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	0.433	0.225	0.164	0.131	0.110	0.095	0.084	0.075	0.067	0.061	0.056
1st Order Decay	0.433	0.120	0.046	0.020	0.009	0.004	0.002	0.001	0.000	0.000	0.000
Inst. Reaction	0.433	0.225	0.164	0.131	0.110	0.095	0.084	0.075	0.067	0.061	0.056
Field Data from Site	1.100				0.460				0.086		



Calculate Animation

Time:

100 Years

Return to Input

Recalculate This Sheet

Input screen for Low K BIOSCREEN Total Xylenes model run with source concentration taken from Table 2-9

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence

Version 1.4

CRS
Total Xylenes
Run Name

1. HYDROGEOLOGY

Seepage Velocity* Vs 11.1 (ft/yr)
or
Hydraulic Conductivity K 3.4E-05 (cm/sec)
Hydraulic Gradient i 0.0628 (ft/ft)
Porosity n 0.2 (-)

2. DISPERSION

Longitudinal Dispersivity* alpha x 50.0 (ft)
Transverse Dispersivity* alpha y 5.0 (ft)
Vertical Dispersivity* alpha z 0.1 (ft)
or
Estimated Plume Length Lp 200 (ft)

3. ADSORPTION

Retardation Factor* R 1.0 (-)
or
Soil Bulk Density rho 1.7 (kg/l)
Partition Coefficient Koc 38 (L/kg)
Fraction Organic Carbon foc 5.7E-5 (-)

4. BIODEGRADATION

1st Order Decay Coeff* lambda 2.2E+0 (per yr)
or
Solute Half-Life t-half 0.08 (year)
or Instantaneous Reaction Model

Delta Oxygen* DO (mg/L)
Delta Nitrate* NO3 (mg/L)
Observed Ferrous Iron* Fe2+ (mg/L)
Delta Sulfate* SO4 (mg/L)
Observed Methane* CH4 (mg/L)

5. GENERAL

Modeled Area Length* 200 (ft)
Modeled Area Width* 200 (ft)
Simulation Time* 100 (yr)

6. SOURCE DATA

Source Thickness in Sat Zone* 5 (ft)
Source Zones:

Width* (ft)	Conc. (mg/L)*
4	2.12
4	2.12
4	2.12
4	2.12
4	2.12

Source Half-life (see Help):
Inst React. >1000 (yr)
1st Order >1000 (yr)
Soluble Mass 46000 (Kg)
In Source NAPL, Soil

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	4.8				1.3				.18		
Dist. from Source (ft)	0	20	40	60	85	100	120	140	160	180	200

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

View Output

RUN ARRAY

View Output

Help

Recalculate This Sheet

Paste Example Dataset

Restore Formulas for Vs, Dispersivities, R, lambda, other

Data Input Instructions:

115 or 0.02

1. Enter value directly...or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* → Data used directly in model.
20 → Value calculated by model. (Don't enter any data).

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

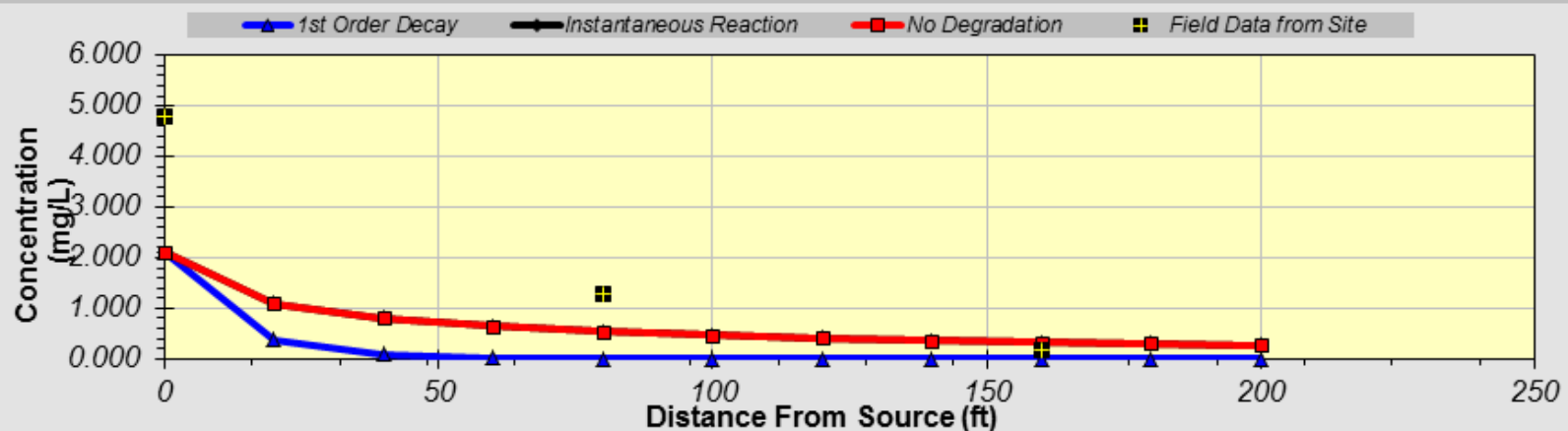
View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

Output screen for Low K BIOSCREEN Total Xylenes model with source concentrations taken from Table 2-9

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	2.120	1.102	0.801	0.644	0.540	0.466	0.409	0.365	0.329	0.300	0.275
1st Order Decay	2.120	0.376	0.093	0.026	0.007	0.002	0.001	0.000	0.000	0.000	0.000
Inst. Reaction	2.120	1.102	0.801	0.644	0.540	0.466	0.409	0.365	0.329	0.300	0.275
Field Data from Site	4.800				1.300				0.180		



Calculate Animation

Time:

100 Years

Return to Input

Recalculate This Sheet



BIOCHLOR / BIOSCREEN High K Simulations

LNAST FRACTURE FLOW

A large, gnarled tree with a thick trunk and dense green foliage, standing on a grassy hill under a clear blue sky. The tree's trunk is twisted and weathered, with a hollowed-out section. The leaves are a vibrant green, and the background shows a clear blue sky and distant hills.

BIOCHLOR Natural Attenuation Decision Support System

Version 2.2
Excel 2000

CRS

MW-14A to MW-11A

Run Name

Data Input Instructions:

115 → 1. Enter value directly....or
↑ or 2. Calculate by filling in gray
0.02 cells. Press Enter, then **C**
(To restore formulas, hit "Restore Formulas" button)
Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT:

Ethenes ☒ **Ethanes** ☐

1. ADVECTION

Seepage Velocity* Vs (ft/yr) **C**

or

Hydraulic Conductivity K (cm/sec)

Hydraulic Gradient i (ft/ft)

Effective Porosity n (-)

2. DISPERSION

Alpha x* (ft)

(Alpha y) / (Alpha x)* (-)

(Alpha z) / (Alpha x)* (-)

3. ADSORPTION

Retardation Factor* **C**

or

Soil Bulk Density, rho (kg/L)

Fraction Organic Carbon, f_{oc} (-)

Partition Coefficient K_{oc}

	(L/kg)		(-)
PCE	426	1.00	(-)
TCE	130	1.00	(-)
DCE	125	1.00	(-)
VC	30	1.00	(-)
ETH	302	1.00	(-)

Common R (used in model)* = **C**

4. BIOTRANSFORMATION

1st Order Decay Coefficient* **C**

Zone 1

PCE → TCE

TCE → DCE

DCE → VC

VC → ETH

λ (1/yr)

0.000

7.000

0.700

0.500

half-life (yrs)

Yield

0.79

0.74

0.64

0.45

Zone 2

PCE → TCE

TCE → DCE

DCE → VC

VC → ETH

λ (1/yr)

0.000

0.000

0.000

0.000

half-life (yrs)

λ HELP

5. GENERAL

Simulation Time* (yr)

Modeled Area Width* (ft)

Modeled Area Length* (ft)

Zone 1 Length* (ft)

Zone 2 Length* (ft)

6. SOURCE DATA

Source Options

TYPE: Continuous Single Planar

Source Thickness in Sat. Zone* (ft)

Width* (ft)

Conc. (mg/L)* C1

PCE	0
TCE	4.12
DCE	2.98
VC	0
ETH	0

7. FIELD DATA FOR COMPARISON

	1.0	16.0	50.0	1.0	.165	.165	8.2	.165	.032	.019	.96	.48
PCE Conc. (mg/L)												
TCE Conc. (mg/L)												
DCE Conc. (mg/L)												
VC Conc. (mg/L)												
ETH Conc. (mg/L)												

Distance from Source (ft)

Date Data Collected

2011

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

RUN ARRAY

Help

Restore

RESET

SEE OUTPUT

Paste

Unprotect

View of Plume Looking Down

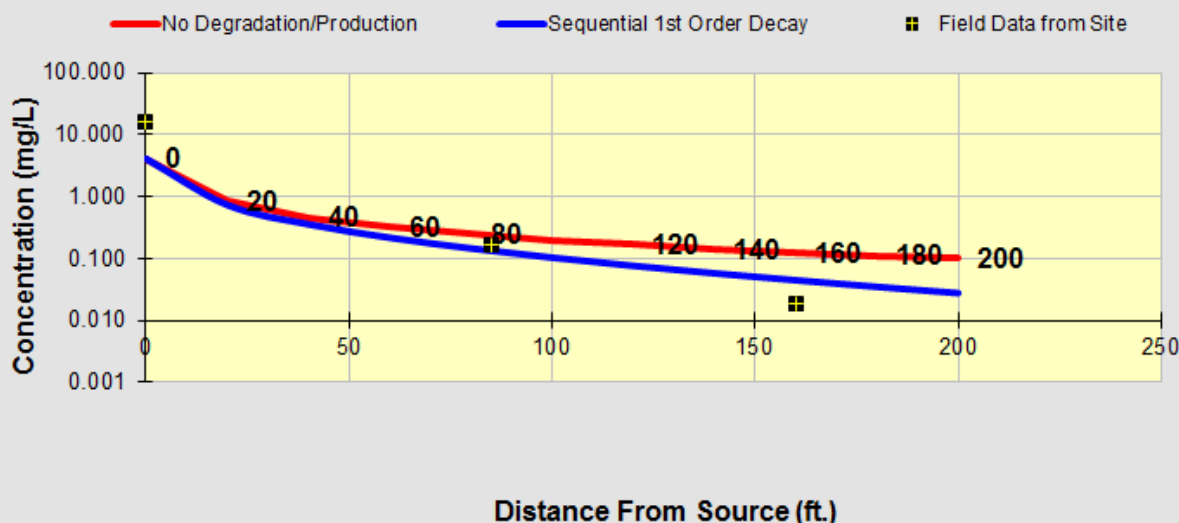
Observed Centerline Conc. at Monitoring Wells

Output screen for High K BIOCHLOR TCE model with source concentrations taken from Table 2-9

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

TCE	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	4.120	0.838	0.464	0.321	0.245	0.198	0.166	0.143	0.126	0.112	0.101
Biotransformation	4.1200	0.736	0.358	0.217	0.146	0.103	0.076	0.058	0.044	0.035	0.028

Field Data from Site	Monitoring Well Locations (ft)										
	0	10	20	40	60	85	100	120	140	160	220
Field Data from Site	16.000					0.165				0.019	

[See PCE](#)[See TCE](#)[See DCE](#)[See VC](#)[See ETH](#)[Prepare Animation](#)

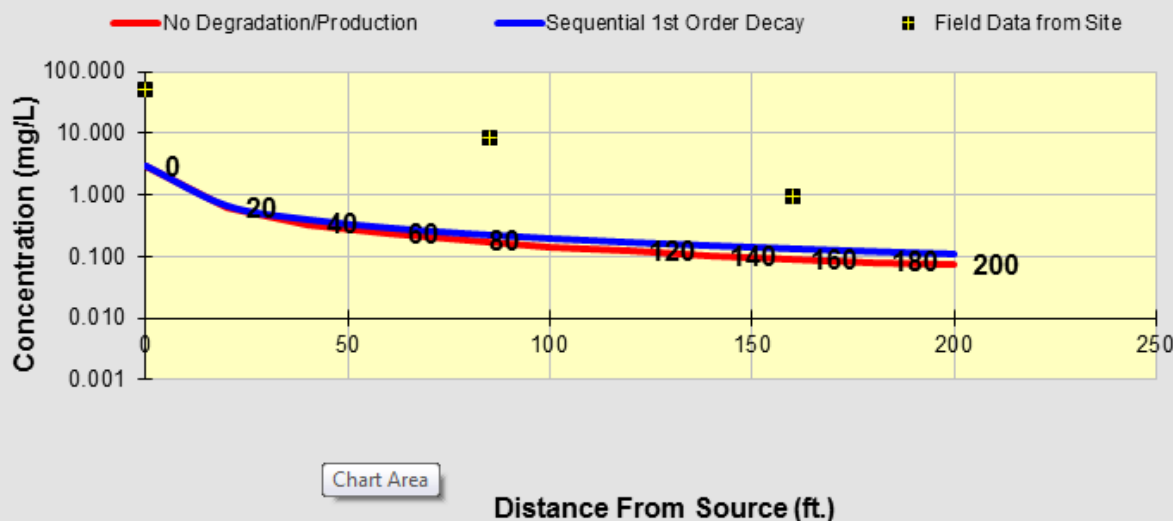
Time:

Log ☐ Linear[Unprotect Sheet](#)[Return to Input](#)[To All](#)[To Array](#)

Output screen for High K BIOCHLOR DCE model with source concentrations taken from Table 2-9

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

DCE	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	2.980	0.606	0.336	0.232	0.177	0.143	0.120	0.104	0.091	0.081	0.073
Biotransformation	2.9800	0.669	0.400	0.293	0.234	0.197	0.170	0.150	0.134	0.121	0.110
	Monitoring Well Locations (ft)										
	0	10	20	40	60	85	100	120	140	160	220
Field Data from Site	50.000					8.200				0.960	

[See PCE](#)[See TCE](#)[See DCE](#)[See VC](#)[See ETH](#)[Prepare Animation](#)

Time:

Log ↔ Linear

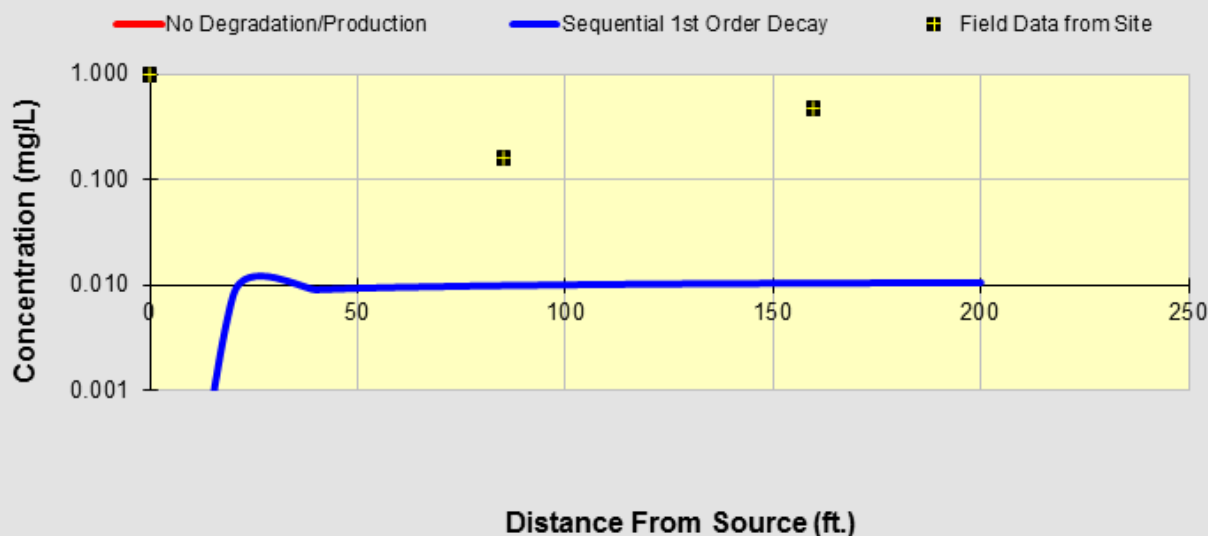
[Unprotect Sheet](#)[Return to Input](#)[To All](#)[To Array](#)

Output screen for High K BIOCHLOR VC model with source concentrations taken from Table 2-9

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

VC	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biotransformation	0.0000	0.008	0.009	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.011

Field Data from Site	Monitoring Well Locations (ft)										
	0	10	20	40	60	85	100	120	140	160	220
Field Data from Site	1.000					0.165				0.480	

[See PCE](#)[See TCE](#)[See DCE](#)[See VC](#)[See ETH](#)[Prepare Animation](#)

Time:

100.0 Years

Log ↔ Linear

[Unprotect Sheet](#)[Return to Input](#)[To All](#)[To Array](#)

Input screen for High K BIOCHLOR

Naphthalene model run with source concentration taken from Table 2-9

BIOCHLOR Natural Attenuation Decision Support System

Version 2.2
Excel 2000

TYPE OF CHLORINATED SOLVENT: Ethenes ☒ Ethanes ☐

1. ADVECTION

Seepage Velocity* Vs (ft/yr) C

Hydraulic Conductivity K (cm/sec)

Hydraulic Gradient i (ft/ft)

Effective Porosity n (-)

2. DISPERSION

Alpha x* (ft)

(Alpha y) / (Alpha x)* (-)

(Alpha z) / (Alpha x)* (-)

3. ADSORPTION

Retardation Factor* C

Soil Bulk Density, rho (kg/L)

Fraction Organic Carbon, f_{oc} (-)

Partition Coefficient K_{oc}

PCE	426	(L/kg)	1.00	(-)
TCE	130	(L/kg)	1.00	(-)
DCE	125	(L/kg)	1.00	(-)
VC	30	(L/kg)	1.00	(-)
ETH	302	(L/kg)	1.00	(-)

Common R (used in model)* = C

4. BIOTRANSFORMATION

Zone 1 ☒ C

PCE → TCE	<input type="text" value="6.000"/> (1/yr)	half-life (yrs)	Yield
TCE → DCE	<input type="text" value="0.000"/>		0.79
DCE → VC	<input type="text" value="0.000"/>		0.74
VC → ETH	<input type="text" value="0.000"/>		0.64

Zone 2 ☐

PCE → TCE	<input type="text" value="0.000"/> (1/yr)	half-life (yrs)	
TCE → DCE	<input type="text" value="0.000"/>		
DCE → VC	<input type="text" value="0.000"/>		
VC → ETH	<input type="text" value="0.000"/>		

5. GENERAL

Simulation Time* (yr)

Modeled Area Width* (ft)

Modeled Area Length* (ft)

Zone 1 Length* (ft)

Zone 2 Length* (ft)

Zone 2 = L - Zone 1

6. SOURCE DATA

Source Options

TYPE: Continuous Single Planar

Source Thickness in Sat. Zone* (ft)

Width* (ft) Y1

Conc. (mg/L)* C1

PCE	<input type="text" value="1.97"/>
TCE	
DCE	
VC	
ETH	

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)	7.405								.052						.011	
TCE Conc. (mg/L)																
DCE Conc. (mg/L)																
VC Conc. (mg/L)																
ETH Conc. (mg/L)																
Distance from Source (ft)	0	10	20	40	60	85	100	120	140	160	220					
Date Data Collected	2011															

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

RUN ARRAY

Help

Restore

RESET

SEE OUTPUT

Paste

Unprotect

Data Input Instructions:

115 → 1. Enter value directly....or
↑ or 0.02 → 2. Calculate by filling in gray cells. Press Enter, then **C**

(To restore formulas, hit "Restore Formulas" button)
Variable* → Data used directly in model.

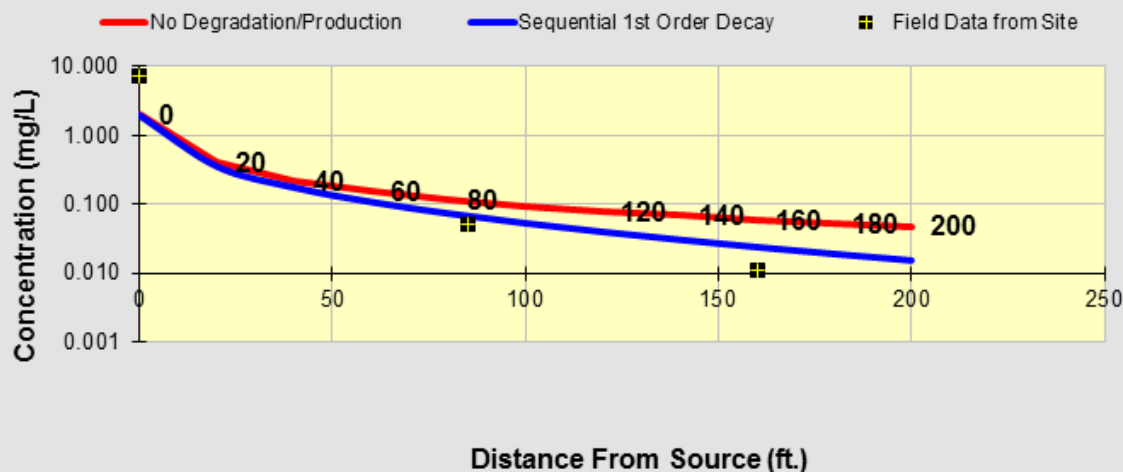
Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

Output screen for High K BIOCHLOR Naphthalene model with source concentrations taken from Table 2-9

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

PCE	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	1.970	0.401	0.222	0.153	0.117	0.095	0.080	0.069	0.060	0.054	0.048
Biotransformation	1.9700	0.357	0.176	0.109	0.074	0.053	0.040	0.031	0.024	0.019	0.015

Field Data from Site	Monitoring Well Locations (ft)										
	0	10	20	40	60	85	100	120	140	160	220
	7.405					0.052				0.011	



See PCE

See TCE

See DCE

See VC

See ETH

Chart Area

Prepare Animation

Time:

100.0 Years

Log ↔ Linear

Unprotect
Sheet

Return to
Input

To All

To Array

Input screen for High K BIOSCREEN

Benzene model run with source concentration taken from Table 2-9

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence

Version 1.4

CRS
Benzene
Run Name

1. HYDROGEOLOGY

Seepage Velocity* Vs 812.8 (ft/yr)
or
Hydraulic Conductivity K 2.5E-03 (cm/sec)
Hydraulic Gradient i 0.0628 (ft/ft)
Porosity n 0.2 (-)

2. DISPERSION

Longitudinal Dispersivity* alpha x 50.0 (ft)
Transverse Dispersivity* alpha y 5.0 (ft)
Vertical Dispersivity* alpha z 0.1 (ft)
or
Estimated Plume Length Lp 200 (ft)

3. ADSORPTION

Retardation Factor* R 1.0 (-)
or
Soil Bulk Density rho 1.7 (kg/l)
Partition Coefficient Koc 38 (L/kg)
Fraction Organic Carbon foc 5.7E-5 (-)

4. BIODEGRADATION

1st Order Decay Coeff* lambda 5.6E-1 (per yr)
or
Solute Half-Life t-half (year)
or **Instantaneous Reaction Model**

Delta Oxygen* DO (mg/L)
Delta Nitrate* NO3 (mg/L)
Observed Ferrous Iron* Fe2+ (mg/L)
Delta Sulfate* SO4 (mg/L)
Observed Methane* CH4 (mg/L)

5. GENERAL

Modeled Area Length* 200 (ft)
Modeled Area Width* 200 (ft)
Simulation Time* 100 (yr)

6. SOURCE DATA

Source Thickness in Sat. Zone* 5 (ft)

Source Zones:

Width* (ft)	Conc. (mg/L)*
4	0.786
4	0.786
4	0.786
4	0.786
4	0.786

Source Half-life (see Help):
>1000 >1000 (yr)
Inst. React. 1st Order
Soluble Mass 46000 (Kg)
In Source NAPL, Soil

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	6.3				.84				.62		
Dist. from Source (ft)	0	20	40	60	85	100	120	140	160	180	200

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

View Output

RUN ARRAY

View Output

Help

Recalculate This Sheet

Paste Example Dataset

Restore Formulas for Vs, Dispersivities, R, lambda, other

Data Input Instructions:

115 or 0.02

1. Enter value directly....or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* Data used directly in model.
20 Value calculated by model. (Don't enter any data).

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

View of Plume Looking Down

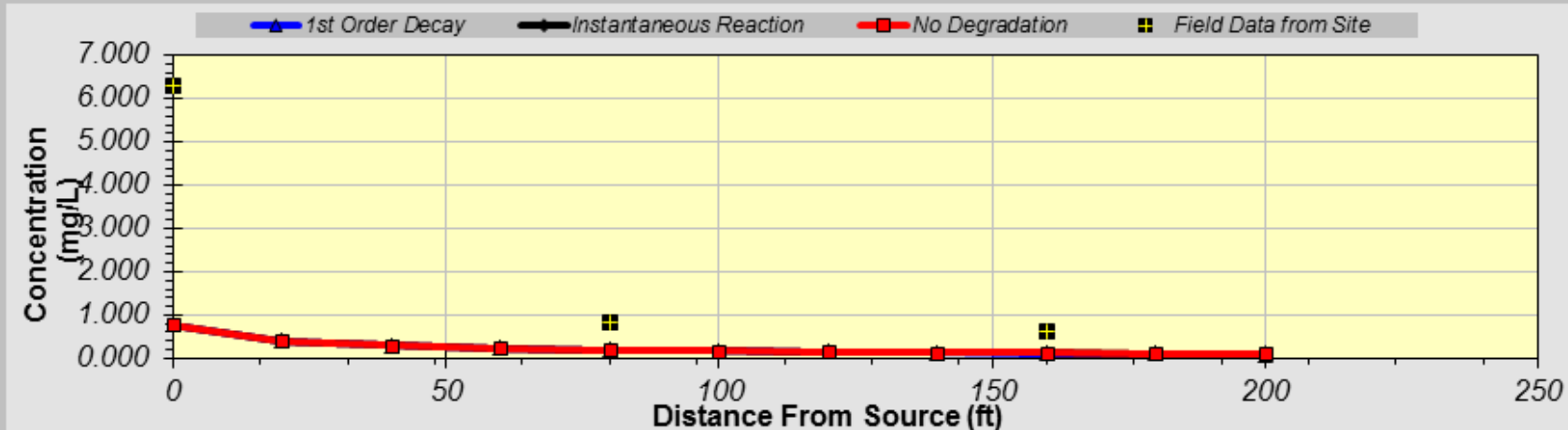
Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

Output screen for High K BIOSCREEN

Benzene model with source concentrations taken from Table 2-9

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	0.785	0.409	0.297	0.239	0.200	0.173	0.152	0.135	0.122	0.111	0.102
1st Order Decay	0.785	0.403	0.289	0.229	0.190	0.162	0.140	0.123	0.110	0.099	0.090
Inst. Reaction	0.785	0.409	0.297	0.239	0.200	0.173	0.152	0.135	0.122	0.111	0.102
Field Data from Site	6.300				0.840				0.620		



Calculate Animation

Time:

100 Years

Return to Input

Recalculate This Sheet

Input screen for High K BIOSCREEN

Toluene model run with source concentration taken from Table 2-9

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence

Version 1.4

CRS
Toluene
Run Name

1. HYDROGEOLOGY

Seepage Velocity* Vs 812.8 (ft/yr)
or
Hydraulic Conductivity K 2.5E-03 (cm/sec)
Hydraulic Gradient i 0.0628 (ft/ft)
Porosity n 0.2 (-)

2. DISPERSION

Longitudinal Dispersivity* alpha x 50.0 (ft)
Transverse Dispersivity* alpha y 5.0 (ft)
Vertical Dispersivity* alpha z 0.1 (ft)
or
Estimated Plume Length Lp 200 (ft)

3. ADSORPTION

Retardation Factor* R 1.0 (-)
or
Soil Bulk Density rho 1.7 (kg/l)
Partition Coefficient Koc 38 (L/kg)
Fraction Organic Carbon foc 5.7E-5 (-)

4. BIODEGRADATION

1st Order Decay Coeff* lambda 9.5E+0 (per yr)
or
Solute Half-Life t-half 0.08 (year)
or Instantaneous Reaction Model

Delta Oxygen* DO (mg/L)
Delta Nitrate* NO3 (mg/L)
Observed Ferrous Iron* Fe2+ (mg/L)
Delta Sulfate* SO4 (mg/L)
Observed Methane* CH4 (mg/L)

5. GENERAL

Modeled Area Length* 200 (ft)
Modeled Area Width* 200 (ft)
Simulation Time* 100 (yr)

6. SOURCE DATA

Source Thickness in Sat Zone* 5 (ft)
Source Zones:

Width* (ft)	Conc. (mg/L)*
4	7.39
4	7.39
4	7.39
4	7.39
4	7.39

Source Half-life (see Help):
Inst. React. >1000 (yr)
Soluble Mass 46000 (Kg)
In Source NAPL Soil

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	40.0				.68			.12			
Dist. from Source (ft)	0	20	40	60	85	100	120	140	160	180	200

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

View Output

RUN ARRAY

View Output

Help

Recalculate This Sheet

Paste Example Dataset

Restore Formulas for Vs, Dispersivities, R, lambda, other

Data Input Instructions:

115 or 0.02
Variable* 20
1. Enter value directly....or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).
Variable* Data used directly in model.
20 Value calculated by model. (Don't enter any data).

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

View of Plume Looking Down

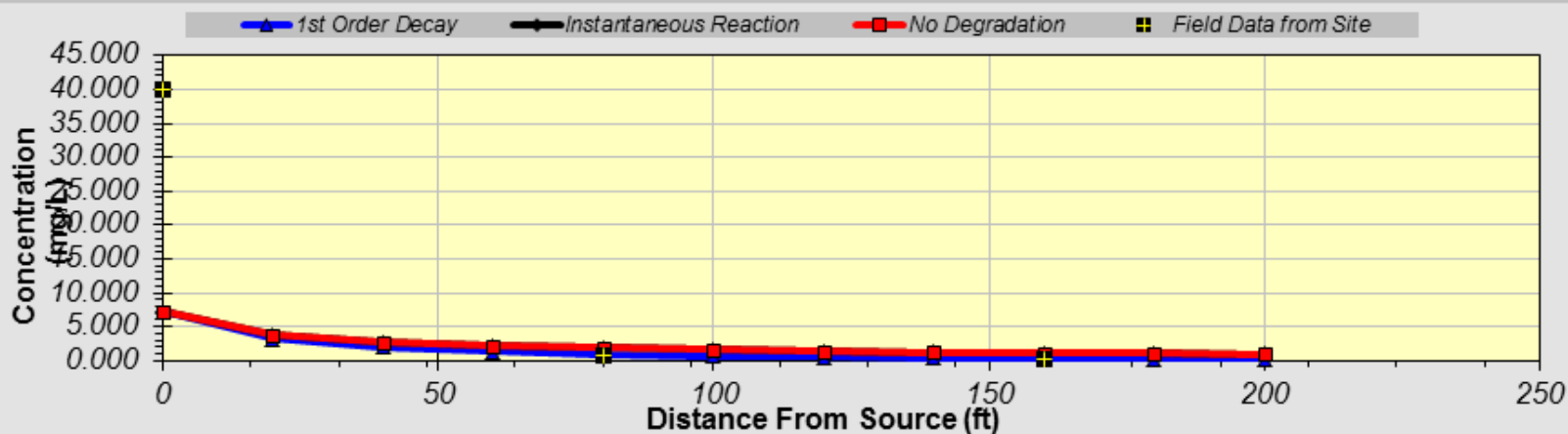
Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

Output screen for High K BIOSCREEN

Toluene model with source concentrations taken from Table 2-9

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	7.336	3.817	2.774	2.229	1.871	1.613	1.418	1.265	1.142	1.041	0.956
1st Order Decay	7.336	3.235	1.993	1.357	0.965	0.706	0.526	0.398	0.304	0.235	0.183
Inst. Reaction	7.336	3.817	2.774	2.229	1.871	1.613	1.418	1.265	1.142	1.041	0.956
Field Data from Site	40.000				0.680				0.120		



Calculate
Animation

Time:

100 Years

Return to
Input

Recalculate This
Sheet

Input screen for High K BIOSCREEN

Ethylbenzene model run with source concentration taken from Table 2-9

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence

Version 1.4

CRS

Ethylbenzene

Run Name

Data Input Instructions:

1. Enter value directly....or
 2. Calculate by filling in grey cells below. (To restore formulas, hit button below).
- Variable* → Data used directly in model.
- 20 → Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity* Vs 812.1 (ft/yr)
 or
 Hydraulic Conductivity K 2.5E-03 (cm/sec)
 Hydraulic Gradient i 0.0628 (ft/ft)
 Porosity n 0.2 (-)

2. DISPERSION

Longitudinal Dispersivity* alpha x 50.0 (ft)
 Transverse Dispersivity* alpha y 5.0 (ft)
 Vertical Dispersivity* alpha z 0.1 (ft)
 or
 Estimated Plume Length Lp 200 (ft)

3. ADSORPTION

Retardation Factor* R 1.0 (-)
 or
 Soil Bulk Density rho 1.7 (kg/l)
 Partition Coefficient Koc 38 (L/kg)
 Fraction Organic Carbon foc 5.7E-5 (-)

4. BIODEGRADATION

1st Order Decay Coeff* lambda 9.0E-1 (per yr)
 or
 Solute Half-Life t-half 0.08 (year)
 or Instantaneous Reaction Model
 Delta Oxygen* DO (mg/L)
 Delta Nitrate* NO3 (mg/L)
 Observed Ferrous Iron* Fe2+ (mg/L)
 Delta Sulfate* SO4 (mg/L)
 Observed Methane* CH4 (mg/L)

5. GENERAL

Modeled Area Length* 200 (ft)
 Modeled Area Width* 200 (ft)
 Simulation Time* 100 (yr)

6. SOURCE DATA

Source Thickness in Sat Zone* 5 (ft)

Source Zones:

Width* (ft)	Conc. (mg/L)*
4	0.433
4	0.433
4	0.433
4	0.433
4	0.433

Source Halflife (see Help):

>1000 >1000 (yr)

Inst React 1st Order

Soluble Mass 46000 (Kg)

In Source NAPL Soil

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	1.1				.46				.086		
Dist. from Source (ft)	0	20	40	60	85	100	120	140	160	180	200

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN
CENTERLINE

View Output

RUN ARRAY

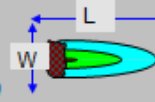
View Output

Help

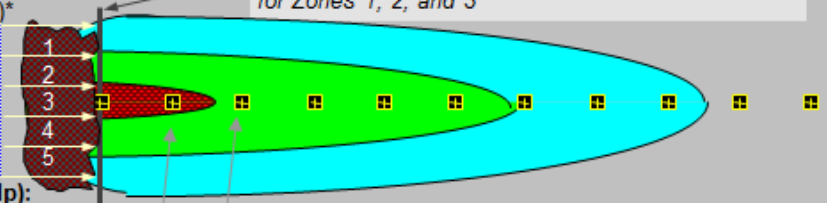
Recalculate
This Sheet

Paste Example Dataset

Restore Formulas for Vs,
Dispersivities, R, lambda, other



Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

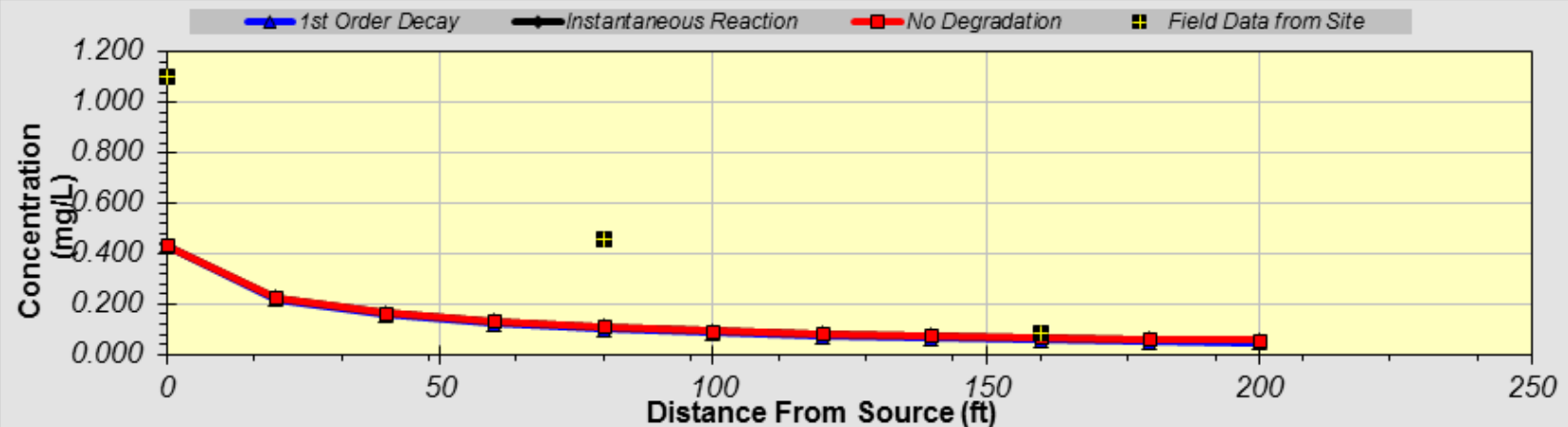
Output screen for High K BIOSCREEN

Ethylbenzene model with source concentrations taken from Table 2-9

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

Distance from Source (ft)

TYPE OF MODEL	0	20	40	60	80	100	120	140	160	180	200
No Degradation	0.433	0.225	0.164	0.132	0.110	0.095	0.084	0.075	0.067	0.061	0.056
1st Order Decay	0.433	0.220	0.157	0.123	0.101	0.086	0.074	0.064	0.057	0.051	0.046
Inst. Reaction	0.433	0.225	0.164	0.132	0.110	0.095	0.084	0.075	0.067	0.061	0.056
Field Data from Site	1.100				0.460				0.086		



Calculate
Animation

Time:

100 Years

Return to
Input

Recalculate This
Sheet

Input screen for High K BIOSCREEN Total Xylenes model run with source concentration taken from Table 2-9

BIOSCREEN Natural Attenuation Decision Support System
Air Force Center for Environmental Excellence

Version 1.4

CRS
Total Xylenes
Run Name

1. HYDROGEOLOGY

Seepage Velocity* Vs 812.8 (ft/yr)
or
Hydraulic Conductivity K 2.5E-03 (cm/sec)
Hydraulic Gradient i 0.0628 (ft/ft)
Porosity n 0.2 (-)

2. DISPERSION

Longitudinal Dispersivity* alpha x 50.0 (ft)
Transverse Dispersivity* alpha y 5.0 (ft)
Vertical Dispersivity* alpha z 0.1 (ft)
or
Estimated Plume Length Lp 200 (ft)

3. ADSORPTION

Retardation Factor* R 1.0 (-)
or
Soil Bulk Density rho 1.7 (kg/l)
Partition Coefficient Koc 38 (L/kg)
Fraction Organic Carbon foc 5.7E-5 (-)

4. BIODEGRADATION

1st Order Decay Coeff* lambda 2.2E+0 (per yr)
or
Solute Half-Life t-half 0.08 (year)
or Instantaneous Reaction Model

Delta Oxygen* DO (mg/L)
Delta Nitrate* NO3 (mg/L)
Observed Ferrous Iron* Fe2+ (mg/L)
Delta Sulfate* SO4 (mg/L)
Observed Methane* CH4 (mg/L)

5. GENERAL

Modeled Area Length* 200 (ft)
Modeled Area Width* 200 (ft)
Simulation Time* 100 (yr)

6. SOURCE DATA

Source Thickness in Sat.Zone* 5 (ft)

Source Zones:

Width* (ft)	Conc. (mg/L)*
4	2.12
4	2.12
4	2.12
4	2.12
4	2.12

Source Half-life (see Help):
>1000 (yr)
Inst React 1st Order
Soluble Mass 46000 (Kg)
In Source NAPL, Soil

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	4.8				1.3				.18		
Dist. from Source (ft)	0	20	40	60	85	100	120	140	160	180	200

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE
View Output

RUN ARRAY
View Output

Help
Recalculate This Sheet
Paste Example Dataset
Restore Formulas for Vs, Dispersivities, R, lambda, other

Data Input Instructions:

115 or 0.02
Variable* 20
1. Enter value directly....or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).
Data used directly in model.
Value calculated by model. (Don't enter any data).

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

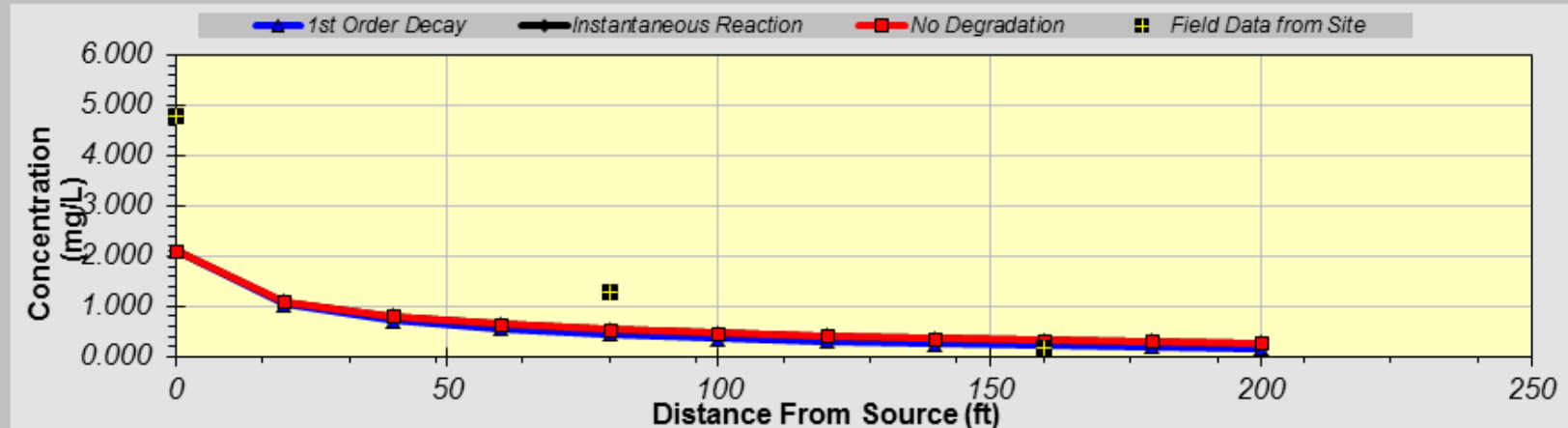
View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

Output screen for High K BIOSCREEN Total Xylenes model with source concentrations taken from Table 2-9

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	2.116	1.101	0.800	0.643	0.540	0.465	0.409	0.365	0.329	0.300	0.276
1st Order Decay	2.116	1.049	0.726	0.556	0.445	0.365	0.306	0.260	0.224	0.194	0.170
Inst. Reaction	2.116	1.101	0.800	0.643	0.540	0.465	0.409	0.365	0.329	0.300	0.276
Field Data from Site	4.800				1.300				0.180		



Calculate Animation

Time:

100 Years

Return to Input

Recalculate This Sheet



BIOCHLOR and BIOSCREEN Simulations from LNAST Modeled Depleted Source Zone

LNAST Model
Representing
Intergranular
Porosity



BIOCHLOR / BIOSCREEN Baseline K Simulations

LNAST INTERGRANULAR POROSITY

Input screen for Baseline K BIOCHLOR TCE, DCE, and VC model runs with source concentrations taken from Table 2-10

BIOCHLOR Natural Attenuation Decision Support System

Version 2.2
Excel 2000

TYPE OF CHLORINATED SOLVENT: Ethenes ☒ Ethanes ☐

1. ADVECTION

Seepage Velocity* Vs 172.2 (ft/yr) C

Hydraulic Conductivity K 5.3E-04 (cm/sec)

Hydraulic Gradient i 0.0628 (ft/ft)

Effective Porosity n 0.2 (-)

2. DISPERSION

Alpha x* 50 (ft)

(Alpha y) / (Alpha x)* 0.1 (-)

(Alpha z) / (Alpha x)* 1.E-02 (-)

3. ADSORPTION

Retardation Factor* R C

Soil Bulk Density, rho 1 (kg/L)

Fraction Organic Carbon, f_{oc} 0.0E+0 (-)

Partition Coefficient K_{oc}

Solute	K _{oc} (L/kg)	R
PCE	426	1.00 (-)
TCE	130	1.00 (-)
DCE	125	1.00 (-)
VC	30	1.00 (-)
ETH	302	1.00 (-)

Common R (used in model)* = 1.00 C

4. BIOTRANSFORMATION

Zone 1

Reaction	λ (1/yr)	half-life (yrs)	Yield
PCE → TCE	0.000		0.79
TCE → DCE	7.000		0.74
DCE → VC	0.700		0.64
VC → ETH	0.500		0.45

Zone 2

Reaction	λ (1/yr)	half-life (yrs)
PCE → TCE	0.000	
TCE → DCE	0.000	
DCE → VC	0.000	
VC → ETH	0.000	

λ HELP

5. GENERAL

Simulation Time* 100 (yr)

Modeled Area Width* 200 (ft)

Modeled Area Length* 200 (ft)

Zone 1 Length* 200 (ft)

Zone 2 Length* 0 (ft)

Zone 2 = L - Zone 1

6. SOURCE DATA

Source Options

TYPE: Continuous Single Planar

Source Thickness in Sat. Zone* 5 (ft)

Width* (ft) 10

Conc. (mg/L)* C1

Solute	Conc. (mg/L)
PCE	.0
TCE	8.65
DCE	13.4
VC	.0
ETH	

k_s* (1/yr)

Solute	k _s * (1/yr)
PCE	0
TCE	0
DCE	0
VC	0
ETH	0

7. FIELD DATA FOR COMPARISON

Distance from Source (ft)	PCE Conc. (mg/L)	TCE Conc. (mg/L)	DCE Conc. (mg/L)	VC Conc. (mg/L)	ETH Conc. (mg/L)
0	1.0	.165	.165	.165	.165
10	16.0	.165	.165	.165	.165
20	50.0	8.2	.165	.165	.165
40	1.0	.165	.165	.165	.165
60					
85					
100					
120					
140					
160					
220					

Date Data Collected 2011

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

RUN ARRAY

Help

SEE OUTPUT

Restore

RESET

Paste

Unprotect

Data Input Instructions:

115 → 1. Enter value directly....or
↑ or 0.02 → 2. Calculate by filling in gray cells. Press Enter, then C

(To restore formulas, hit "Restore Formulas" button)
Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations

View of Plume Looking Down

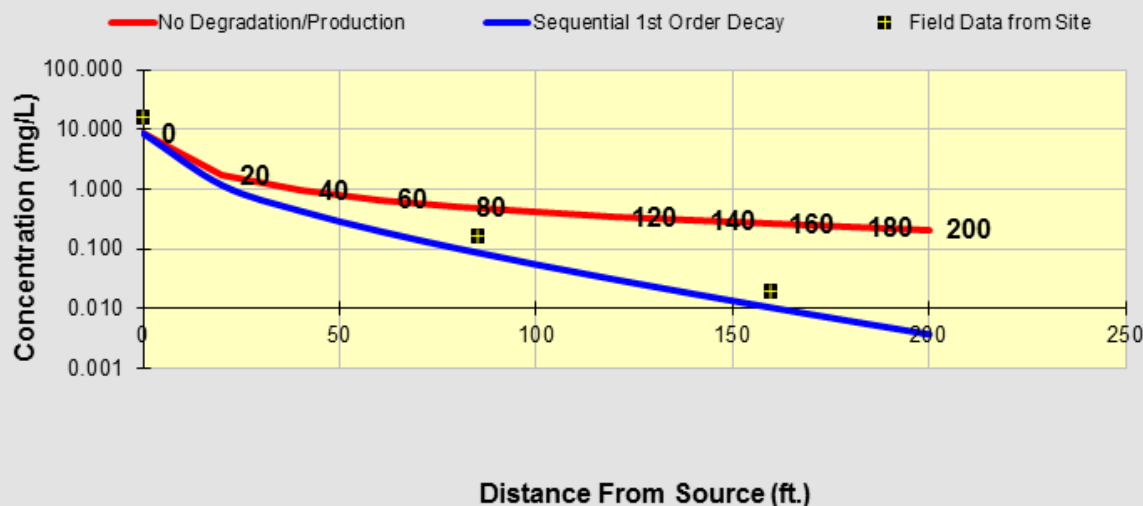
Observed Centerline Conc. at Monitoring Wells

Output screen for Baseline K BIOCHLOR TCE model with source concentrations taken from Table 2-10

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

TCE	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	8.650	1.760	0.975	0.674	0.514	0.416	0.349	0.301	0.264	0.236	0.213
Biotransformation	8.6500	1.175	0.434	0.200	0.102	0.055	0.031	0.018	0.010	0.006	0.004

Field Data from Site	Monitoring Well Locations (ft)										
	0	10	20	40	60	85	100	120	140	160	220
Field Data from Site	16.000					0.165				0.019	



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

100.0 Years

Log ↔ Linear

Unprotect
Sheet

Return to
Input

To All

To Array

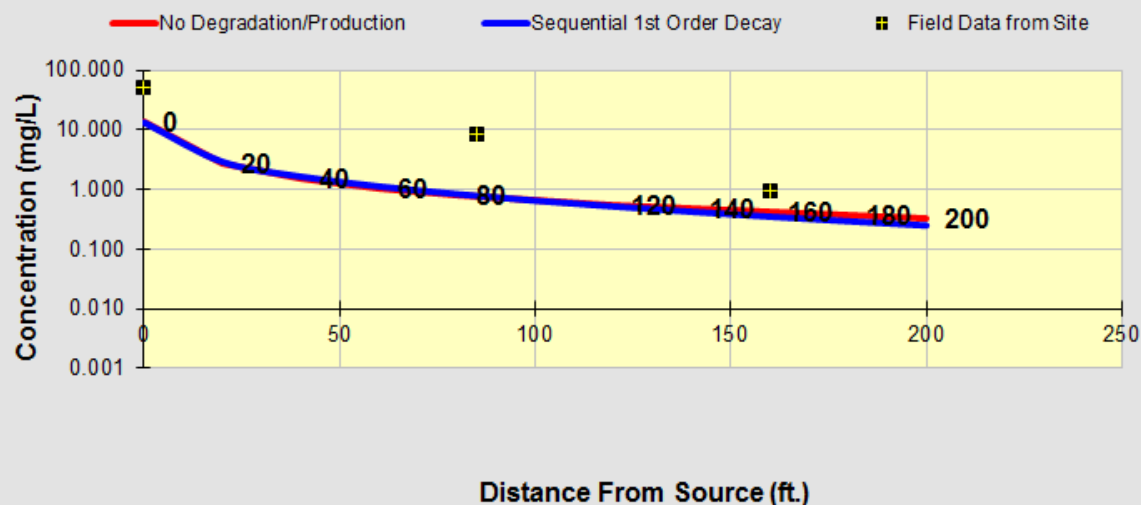
↑
me

Output screen for Baseline K BIOCHLOR DCE model with source concentrations taken from Table 2-10

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

DCE	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	13.400	2.727	1.510	1.043	0.797	0.645	0.541	0.466	0.410	0.365	0.330
Biotransformation	13.4000	2.927	1.654	1.132	0.840	0.652	0.521	0.424	0.351	0.294	0.249

Field Data from Site	Monitoring Well Locations (ft)										
	0	10	20	40	60	85	100	120	140	160	220
Field Data from Site	50.000					8.200				0.960	



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

100.0 Years

Log ↔ Linear

Unprotect
Sheet

Return to
Input

To All

To Array

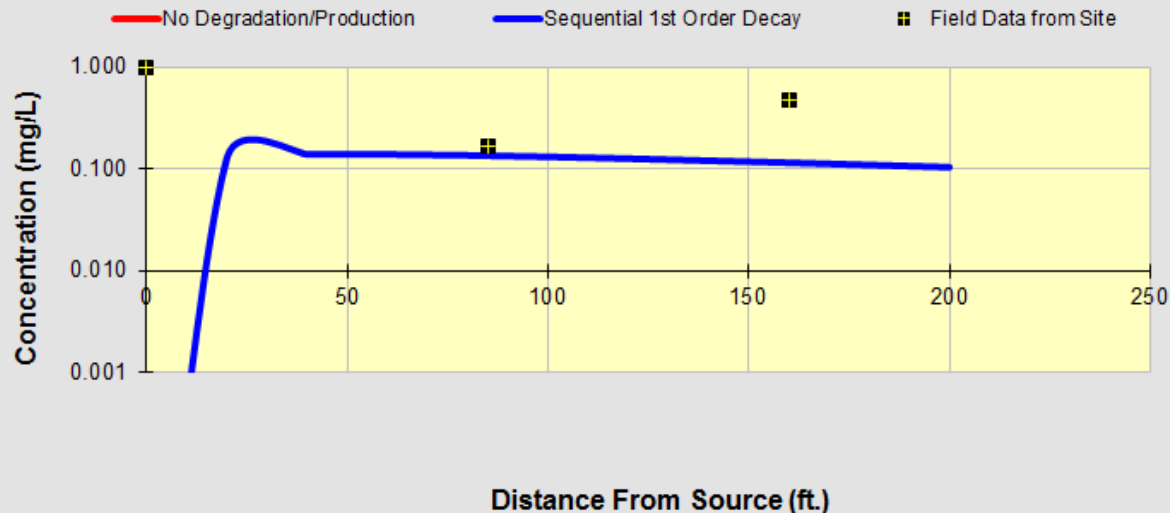
ne

Output screen for Baseline K BIOCHLOR VC model with source concentrations taken from Table 2-10

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

VC	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biotransformation	0.0000	0.130	0.140	0.139	0.136	0.132	0.126	0.121	0.115	0.110	0.104

Field Data from Site	Monitoring Well Locations (ft)										
	0	10	20	40	60	85	100	120	140	160	220
Field Data from Site	1.000					0.165				0.480	

[See PCE](#)[See TCE](#)[See DCE](#)[See VC](#)[See ETH](#)[Prepare Animation](#)

Time:

100.0 Years

Log Linear

[Unprotect Sheet](#)[Return to Input](#)[To All](#)[To Array](#)

Input screen for Baseline K BIOCHLOR Naphthalene model run with source concentration taken from Table 2-10

BIOCHLOR Natural Attenuation Decision Support System
Version 2.2
Excel 2000

CRS_SVOC
MW-14A to MW-11A
Run Name

Data Input Instructions:
115 → 1. Enter value directly....or
↑ or 0.02 → 2. Calculate by filling in gray cells. Press Enter, then **C**
(To restore formulas, hit "Restore Formulas" button)
Variable* → Data used directly in model.
Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT:
Ethenes ☒
Ethanes ☐

1. ADVECTION
Seepage Velocity* Vs 172.2 (ft/yr) **C**
or
Hydraulic Conductivity K 5.3E-04 (cm/sec)
Hydraulic Gradient i 0.0628 (ft/ft)
Effective Porosity n 0.2 (-)

2. DISPERSION
Alpha x* 50 (ft) **Calc. Alpha x**
(Alpha y) / (Alpha x)* 0.1 (-)
(Alpha z) / (Alpha x)* 1.E-02 (-)

3. ADSORPTION
Retardation Factor* R **C**
or
Soil Bulk Density, rho 1 (kg/L)
Fraction Organic Carbon, f_{oc} 0.0E+0 (-)
Partition Coefficient K_{oc}
PCE 426 (L/kg) 1.00 (-)
TCE 130 (L/kg) 1.00 (-)
DCE 125 (L/kg) 1.00 (-)
VC 30 (L/kg) 1.00 (-)
ETH 302 (L/kg) 1.00 (-)
Common R (used in model)* = 1.00

4. BIOTRANSFORMATION
Zone 1
PCE → TCE 6.000 (1/yr) half-life (yrs) 0.79 Yield 0.79
TCE → DCE 0.000 (1/yr) half-life (yrs) 0.74 Yield 0.74
DCE → VC 0.000 (1/yr) half-life (yrs) 0.64 Yield 0.64
VC → ETH 0.000 (1/yr) half-life (yrs) 0.45 Yield 0.45
Zone 2
PCE → TCE 0.000 (1/yr) half-life (yrs) **λ** **HELP**
TCE → DCE 0.000 (1/yr) half-life (yrs)
DCE → VC 0.000 (1/yr) half-life (yrs)
VC → ETH 0.000 (1/yr) half-life (yrs)

5. GENERAL
Simulation Time* 100 (yr)
Modeled Area Width* 200 (ft)
Modeled Area Length* 200 (ft)
Zone 1 Length* 200 (ft)
Zone 2 Length* 0 (ft)
Zone 2 = L - Zone 1

6. SOURCE DATA
Source Options
TYPE: Continuous Single Planar
Source Thickness in Sat. Zone* 5 (ft)
Y1
Width* (ft) 10
Conc. (mg/L)* C1
PCE 3.43
TCE
DCE
VC
ETH
k_s* (1/yr)
0
0
0
0
0
0
View of Plume Looking Down
Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON
PCE Conc. (mg/L) 7.405
TCE Conc. (mg/L)
DCE Conc. (mg/L)
VC Conc. (mg/L)
ETH Conc. (mg/L)
Distance from Source (ft)
Date Data Collected 2011

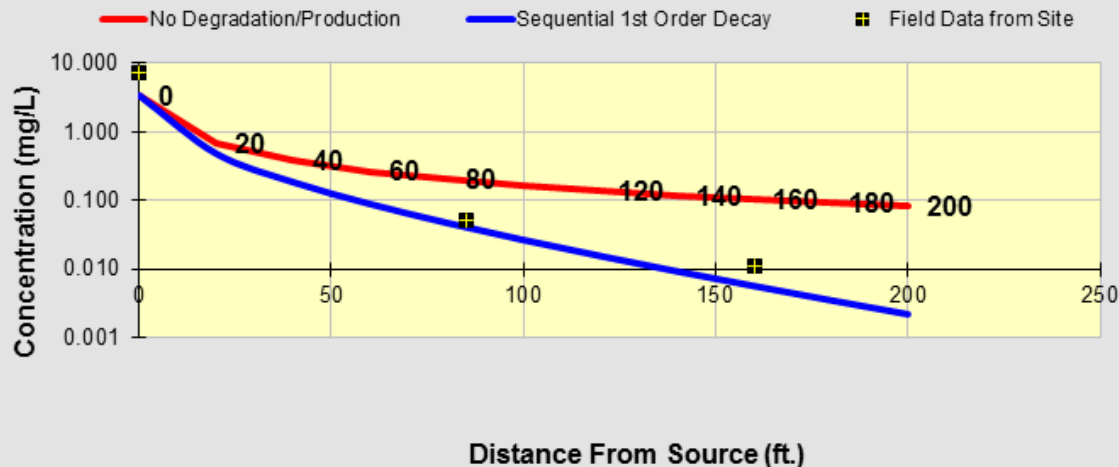
8. CHOOSE TYPE OF OUTPUT TO SEE:
RUN CENTERLINE
RUN ARRAY
Help
SEE OUTPUT
Restore
Paste
RESET
Unprotect

Output screen for Baseline K BIOCHLOR Naphthalene model with source concentrations taken from Table 2-10

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

PCE	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	3.430	0.698	0.387	0.267	0.204	0.165	0.139	0.119	0.105	0.094	0.084
Biotransformation	3.4300	0.485	0.186	0.089	0.047	0.027	0.016	0.009	0.006	0.004	0.002

Field Data from Site	Monitoring Well Locations (ft)										
	0	10	20	40	60	85	100	120	140	160	220
Field Data from Site	7.405					0.052				0.011	

[See PCE](#)[See TCE](#)[See DCE](#)[See VC](#)[See ETH](#)[Prepare Animation](#)

Time:

Log ↔ Linear

[Unprotect
Sheet](#)[Return to
Input](#)[To All](#)[To Array](#)

Input screen for Baseline K BIOSCREEN

Benzene model run with source concentration taken from Table 2-10

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence

Version 1.4

1. HYDROGEOLOGY

Seepage Velocity* Vs 172.2 (ft/yr)
 or
 Hydraulic Conductivity K 5.3E-04 (cm/sec)
 Hydraulic Gradient i 0.0628 (ft/ft)
 Porosity n 0.2 (-)

2. DISPERSION

Longitudinal Dispersivity* α_x 50.0 (ft)
 Transverse Dispersivity* α_y 5.0 (ft)
 Vertical Dispersivity* α_z 0.1 (ft)
 or
 Estimated Plume Length Lp 200 (ft)

3. ADSORPTION

Retardation Factor* R 1.0 (-)
 or
 Soil Bulk Density ρ 1.7 (kg/l)
 Partition Coefficient Koc 38 (L/kg)
 Fraction Organic Carbon foc 5.7E-5 (-)

4. BIODEGRADATION

1st Order Decay Coeff* λ 5.6E-1 (per yr)
 or
 Solute Half-Life t-half (year)
 or Instantaneous Reaction Model
 Delta Oxygen* DO (mg/L)
 Delta Nitrate* NO3 (mg/L)
 Observed Ferrous Iron* Fe2+ (mg/L)
 Delta Sulfate* SO4 (mg/L)
 Observed Methane* CH4 (mg/L)

5. GENERAL

Modeled Area Length* 200 (ft)
 Modeled Area Width* 200 (ft)
 Simulation Time* 100 (yr)

6. SOURCE DATA

Source Thickness in Sat Zone* 5 (ft)

Source Zones:

Width* (ft)	Conc. (mg/L)*
4	1.92
4	1.92
4	1.92
4	1.92
4	1.92

Source Halflife (see Help):

>1000 >1000 (yr)

Inst. React. 1st Order

Soluble Mass 46000 (Kg)

In Source NAPL, Soil

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	6.3				.84				.62			
Dist. from Source (ft)	0	20	40	60	85	100	120	140	160	180	200	

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

View Output

RUN ARRAY

View Output

Help

Recalculate This Sheet

Paste Example Dataset

Restore Formulas for Vs, Dispersivities, R, lambda, other

Data Input Instructions:

115 or 0.02
 Variable* → Data used directly in model.
 20 → Value calculated by model. (Don't enter any data).

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

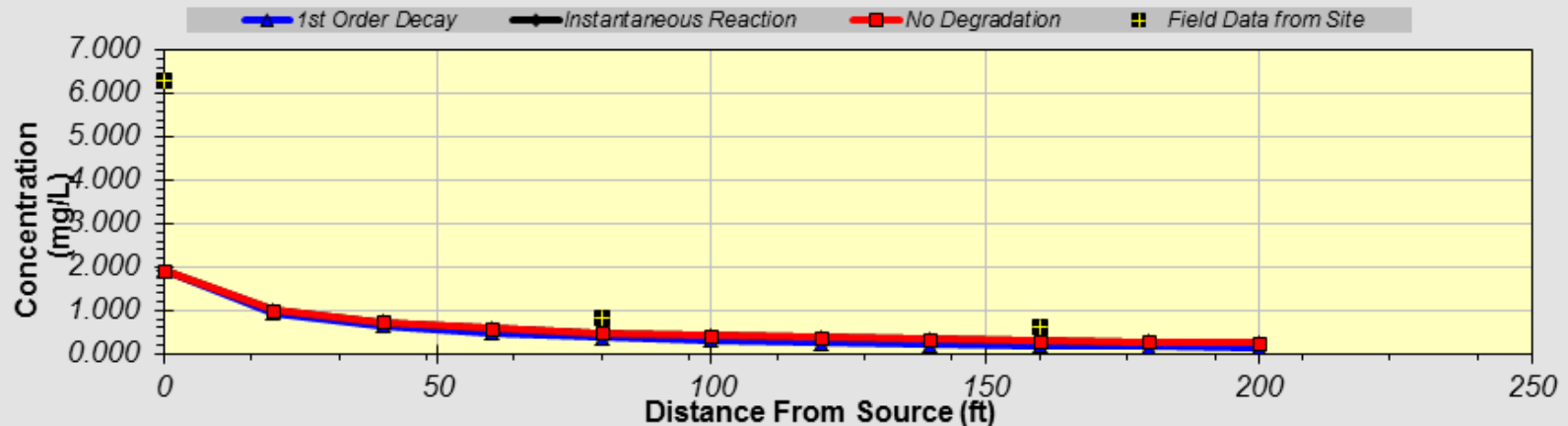
View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
 If No Data Leave Blank or Enter "0"

Output screen for Baseline K BIOSCREEN Benzene model with source concentrations taken from Table 2-10

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	1.919	0.999	0.726	0.583	0.489	0.422	0.371	0.331	0.299	0.272	0.250
1st Order Decay	1.919	0.943	0.648	0.492	0.390	0.318	0.264	0.222	0.189	0.163	0.142
Inst. Reaction	1.919	0.999	0.726	0.583	0.489	0.422	0.371	0.331	0.299	0.272	0.250
Field Data from Site	6.300				0.840				0.620		



Calculate
Animation

Time:

100 Years

Return to
Input

Recalculate This
Sheet

Input screen for Baseline K BIOSCREEN

Toluene model run with source concentration taken from Table 2-10

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence

Version 1.4

CRS

Toluene

Run Name

Data Input Instructions:

1. Enter value directly...or
 2. Calculate by filling in grey cells below. (To restore formulas, hit button below).
- Variable* → Data used directly in model.
- 20 → Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity* Vs 172.2 (ft/yr)
 or
 Hydraulic Conductivity K 5.3E-04 (cm/sec)
 Hydraulic Gradient i 0.0628 (ft/ft)
 Porosity n 0.2 (-)

2. DISPERSION

Longitudinal Dispersivity* alpha x 50.0 (ft)
 Transverse Dispersivity* alpha y 5.0 (ft)
 Vertical Dispersivity* alpha z 0.1 (ft)
 or
 Estimated Plume Length Lp 200 (ft)

3. ADSORPTION

Retardation Factor* R 1.0 (-)
 or
 Soil Bulk Density rho 1.7 (kg/l)
 Partition Coefficient Koc 38 (L/kg)
 Fraction Organic Carbon foc 5.7E-5 (-)

4. BIODEGRADATION

1st Order Decay Coeff* lambda 9.5E+0 (per yr)
 or
 Solute Half-Life t-half 0.08 (year)
 or Instantaneous Reaction Model
 Delta Oxygen* DO (mg/L)
 Delta Nitrate* NO3 (mg/L)
 Observed Ferrous Iron* Fe2+ (mg/L)
 Delta Sulfate* SO4 (mg/L)
 Observed Methane* CH4 (mg/L)

5. GENERAL

Modeled Area Length* 200 (ft)
 Modeled Area Width* 200 (ft)
 Simulation Time* 100 (yr)

6. SOURCE DATA

Source Thickness in Sat. Zone* 5 (ft)

Source Zones:

Width* (ft)	Conc. (mg/L)*
4	13.2
4	13.2
4	13.2
4	13.2
4	13.2

Source Half-life (see Help):

>1000 >1000 (yr)

Inst React 1st Order

Soluble Mass 46000 (Kg)

In Source NAPL, Soil

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	40.0				.68				.12				
Dist. from Source (ft)	0	20	40	60	85	100	120	140	160	180	200		

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

RUN ARRAY

View Output

View Output

Help

Recalculate This Sheet

Paste Example Dataset

Restore Formulas for Vs, Dispersivities, R, lambda, other

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

View of Plume Looking Down

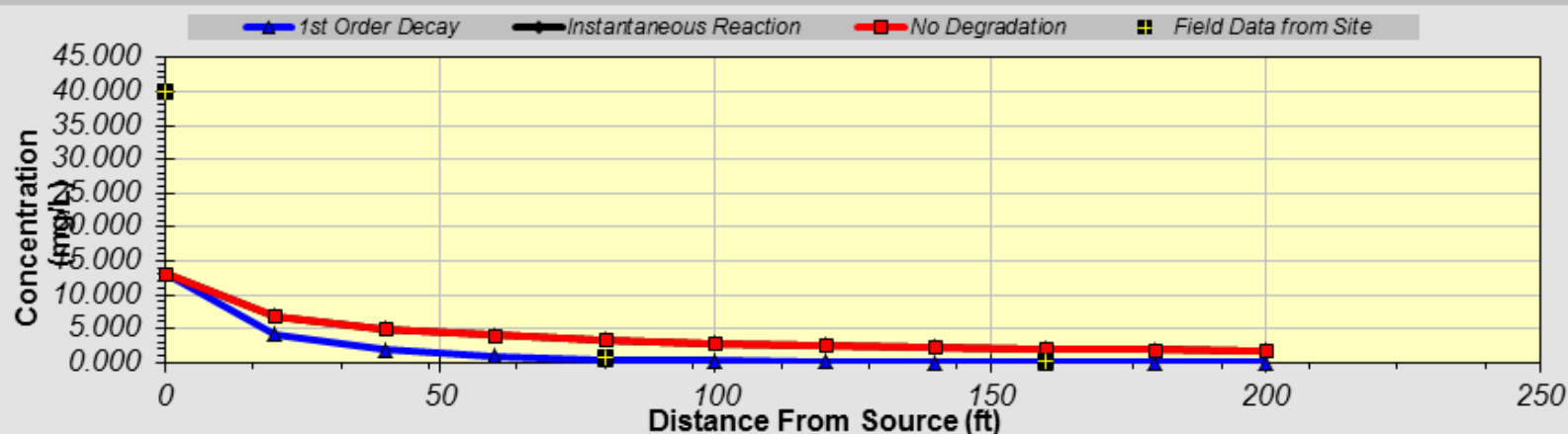
Observed Centerline Concentrations at Monitoring Wells
 If No Data Leave Blank or Enter "0"

Output screen for Baseline K BIOSCREEN

Toluene model with source concentrations taken from Table 2-10

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	13.163	6.849	4.978	4.000	3.357	2.895	2.545	2.271	2.050	1.868	1.715
1st Order Decay	13.163	4.180	1.854	0.909	0.466	0.245	0.132	0.072	0.039	0.022	0.012
Inst. Reaction	13.163	6.849	4.978	4.000	3.357	2.895	2.545	2.271	2.050	1.868	1.715
Field Data from Site	40.000				0.680				0.120		



Calculate Animation

Time:

100 Years

Return to Input

Recalculate This Sheet

Input screen for Baseline K BIOSCREEN

Ethylbenzene model run with source concentration taken from Table 2-10

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence

Version 1.4

CRS
Ethylbenzene
Run Name

Data Input Instructions:

115
↑ or
0.02

1. Enter value directly....or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* → Data used directly in model.
20 → Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity* Vs 172.2 (ft/yr)
or
Hydraulic Conductivity K 5.3E-04 (cm/sec)
Hydraulic Gradient i 0.0628 (ft/ft)
Porosity n 0.2 (-)

2. DISPERSION

Longitudinal Dispersivity* alpha x 50.0 (ft)
Transverse Dispersivity* alpha y 5.0 (ft)
Vertical Dispersivity* alpha z 0.1 (ft)
or
Estimated Plume Length Lp 200 (ft)

3. ADSORPTION

Retardation Factor* R 1.0 (-)
or
Soil Bulk Density rho 1.7 (kg/l)
Partition Coefficient Koc 38 (L/kg)
Fraction Organic Carbon foc 5.7E-5 (-)

4. BIODEGRADATION

1st Order Decay Coeff* lambda 9.0E-1 (per yr)
or
Solute Half-Life t-half 0.08 (year)
or Instantaneous Reaction Model

Delta Oxygen* DO (mg/L)
Delta Nitrate* NO3 (mg/L)
Observed Ferrous Iron* Fe2+ (mg/L)
Delta Sulfate* SO4 (mg/L)
Observed Methane* CH4 (mg/L)

5. GENERAL

Modeled Area Length* 200 (ft)
Modeled Area Width* 200 (ft)
Simulation Time* 100 (yr)

6. SOURCE DATA

Source Thickness in Sat.Zone* 5 (ft)

Source Zones:

Width* (ft)	Conc. (mg/L)*
4	0.707
4	0.707
4	0.707
4	0.707
4	0.707

Source Halflife (see Help):
>1000 >1000 (yr)
Inst. React. ↑ 1st Order
Soluble Mass 46000 (Kg)
In Source NAPL Soil

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	1.1				.46				.086		
Dist. from Source (ft)	0	20	40	60	85	100	120	140	160	180	200

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

View Output

RUN ARRAY

View Output

Help

Recalculate This Sheet

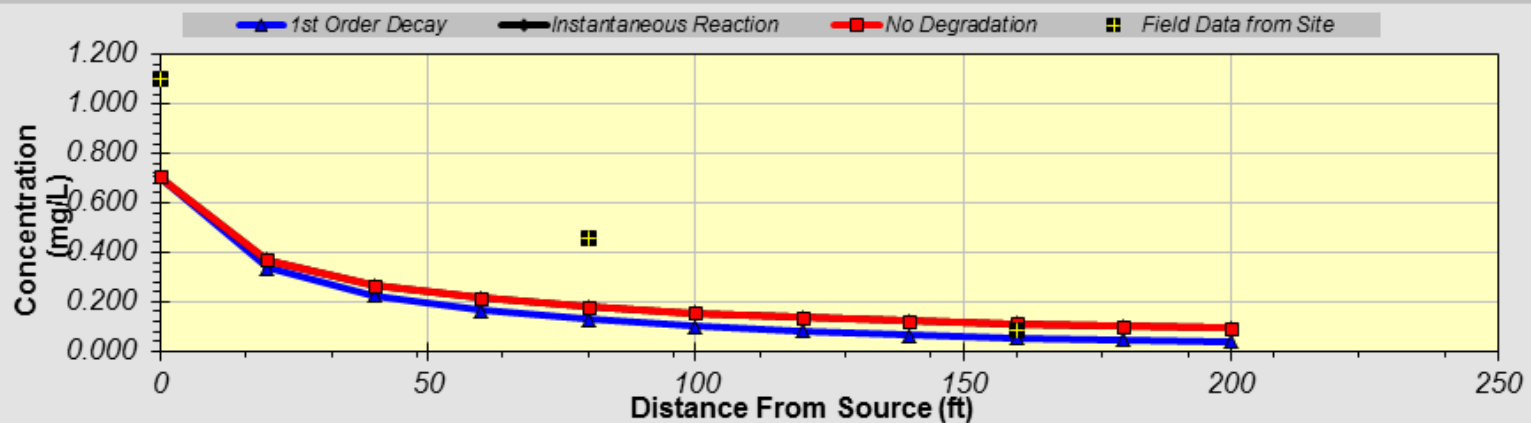
Paste Example Dataset

Restore Formulas for Vs, Dispersivities, R, lambda, other

Output screen for Baseline K BIOSCREEN Ethylbenzene model with source concentrations taken from Table 2-10

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	0.707	0.368	0.267	0.215	0.180	0.155	0.137	0.122	0.110	0.100	0.092
1st Order Decay	0.707	0.337	0.225	0.166	0.128	0.101	0.082	0.067	0.055	0.046	0.039
Inst. Reaction	0.707	0.368	0.267	0.215	0.180	0.155	0.137	0.122	0.110	0.100	0.092
Field Data from Site	1.100				0.460				0.086		



Calculate
Animation

Time:

100 Years

Return to
Input

Recalculate This
Sheet

Input screen for Baseline K BIOSCREEN

Total Xylenes model run with source concentration taken from Table 2-10

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence

Version 1.4

CRS
Total Xylenes
Run Name

1. HYDROGEOLOGY

Seepage Velocity* Vs 172.2 (ft/yr)
or
Hydraulic Conductivity K 5.3E-04 (cm/sec)
Hydraulic Gradient i 0.0628 (ft/ft)
Porosity n 0.2 (-)

2. DISPERSION

Longitudinal Dispersivity* alpha x 50.0 (ft)
Transverse Dispersivity* alpha y 5.0 (ft)
Vertical Dispersivity* alpha z 0.1 (ft)
or
Estimated Plume Length Lp 200 (ft)

3. ADSORPTION

Retardation Factor* R 1.0 (-)
or
Soil Bulk Density rho 1.7 (kg/l)
Partition Coefficient Koc 38 (L/kg)
Fraction Organic Carbon foc 5.7E-5 (-)

4. BIODEGRADATION

1st Order Decay Coeff* lambda 2.2E+0 (per yr)
or
Solute Half-Life t-half 0.08 (year)
or Instantaneous Reaction Model

Delta Oxygen* DO (mg/L)
Delta Nitrate* NO3 (mg/L)
Observed Ferrous Iron* Fe2+ (mg/L)
Delta Sulfate* SO4 (mg/L)
Observed Methane* CH4 (mg/L)

5. GENERAL

Modeled Area Length* 200 (ft)
Modeled Area Width* 200 (ft)
Simulation Time* 100 (yr)

6. SOURCE DATA

Source Thickness in Sat Zone* 5 (ft)

Source Zones:

Width* (ft)	Conc. (mg/L)*
4	3.46
4	3.46
4	3.46
4	3.46
4	3.46

Source Half-life (see Help):
>1000 >1000 (yr)
Inst React 1st Order
Soluble Mass 46000 (Kg)
In Source NAPL, Soil

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	4.8				1.3				.18		
Dist. from Source (ft)	0	20	40	60	85	100	120	140	160	180	200

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

View Output

RUN ARRAY

View Output

Help

Recalculate This Sheet

Paste Example Dataset

Restore Formulas for Vs, Dispersivities, R, lambda, other

Data Input Instructions:

115 or 0.02

1. Enter value directly...or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* → Data used directly in model.
20 → Value calculated by model. (Don't enter any data).

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

View of Plume Looking Down

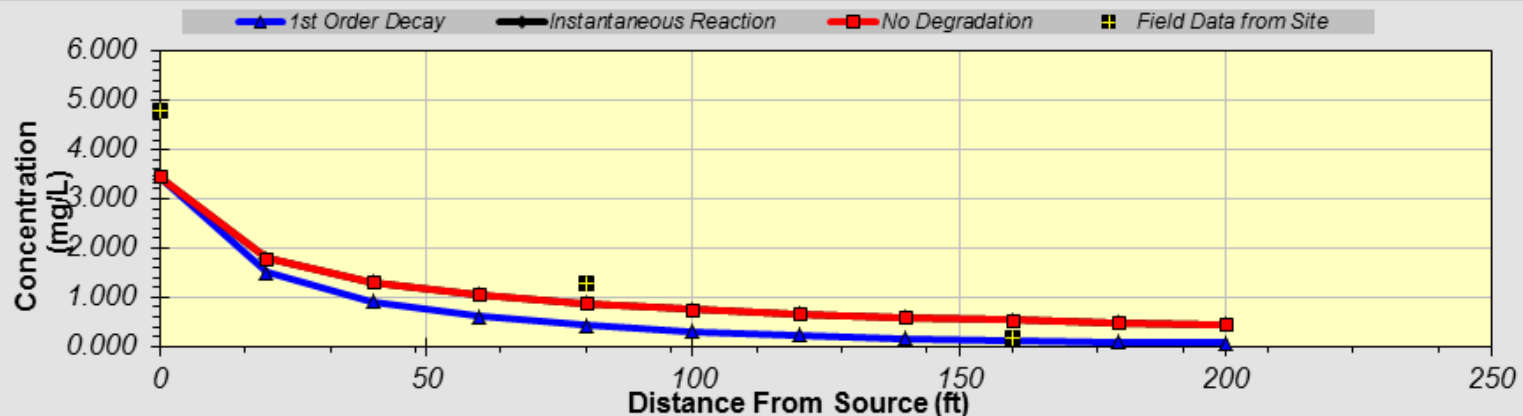
Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

Output screen for Baseline K BIOSCREEN

Total Xylenes model with source concentrations taken from Table 2-10

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	3.457	1.799	1.308	1.051	0.882	0.760	0.668	0.596	0.538	0.491	0.451
1st Order Decay	3.457	1.507	0.918	0.618	0.434	0.314	0.231	0.173	0.131	0.100	0.077
Inst. Reaction	3.457	1.799	1.308	1.051	0.882	0.760	0.668	0.596	0.538	0.491	0.451
Field Data from Site	4.800				1.300				0.180		



Calculate
Animation

Time:

100 Years

Return to
Input

Recalculate This
Sheet



BIOCHLOR / BIOSCREEN Low K Simulations

LNAST FRACTURE FLOW

Input screen for Low K BIOCHLOR TCE, DCE, and VC model runs with source concentrations taken from Table 2-10

BIOCHLOR Natural Attenuation Decision Support System

Version 2.2
Excel 2000

TYPE OF CHLORINATED SOLVENT: Ethenes ☒ Ethanes ☐

1. ADVECTION

Seepage Velocity* Vs (ft/yr) ↑

Hydraulic Conductivity K (cm/sec)

Hydraulic Gradient i (ft/ft)

Effective Porosity n (-)

2. DISPERSION

Alpha x* (ft) Calc. Alpha x

(Alpha y) / (Alpha x)* (-)

(Alpha z) / (Alpha x)* (-)

3. ADSORPTION

Retardation Factor* C

Soil Bulk Density, rho (kg/L)

Fraction Organic Carbon, foc (-)

Partition Coefficient Koc

	Value	Unit	Retardation Factor
PCE	426	(L/kg)	1.00 (-)
TCE	130	(L/kg)	1.00 (-)
DCE	125	(L/kg)	1.00 (-)
VC	30	(L/kg)	1.00 (-)
ETH	302	(L/kg)	1.00 (-)

Common R (used in model)* = ↑ ↓

4. BIOTRANSFORMATION

Zone 1

Zone 2

1st Order Decay Coefficient* C

Process	λ (1/yr)	half-life (yrs)	Yield
PCE → TCE	0.000		0.79
TCE → DCE	7.000		0.74
DCE → VC	0.700		0.64
VC → ETH	0.500		0.45

λ (1/yr) ↑ ↓ λ HELP

5. GENERAL

Simulation Time* (yr)

Modeled Area Width* (ft)

Modeled Area Length* (ft)

Zone 1 Length* (ft)

Zone 2 Length* (ft)

Zone 2 = L - Zone 1

6. SOURCE DATA

Source Options

TYPE: Continuous Single Planar

Source Thickness in Sat. Zone* (ft)

Width* (ft) Y1

Conc. (mg/L)* C1

Compound	Conc. (mg/L)
PCE	.0
TCE	8.65
DCE	13.4
VC	.0
ETH	

View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

Distance from Source (ft)	0	10	20	40	60	85	100	120	140	160	220
PCE Conc. (mg/L)	1.0					.165				.032	
TCE Conc. (mg/L)	16.0					.165				.019	
DCE Conc. (mg/L)	50.0					8.2				.96	
VC Conc. (mg/L)	1.0					.165				.48	
ETH Conc. (mg/L)											

Date Data Collected

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

RUN ARRAY

Help

Restore

RESET

SEE OUTPUT

Paste

Unprotect

Data Input Instructions:

→ 1. Enter value directly....or

↑ or → 2. Calculate by filling in gray cells. Press Enter, then C

(To restore formulas, hit "Restore Formulas" button)

Variable* → Data used directly in model.

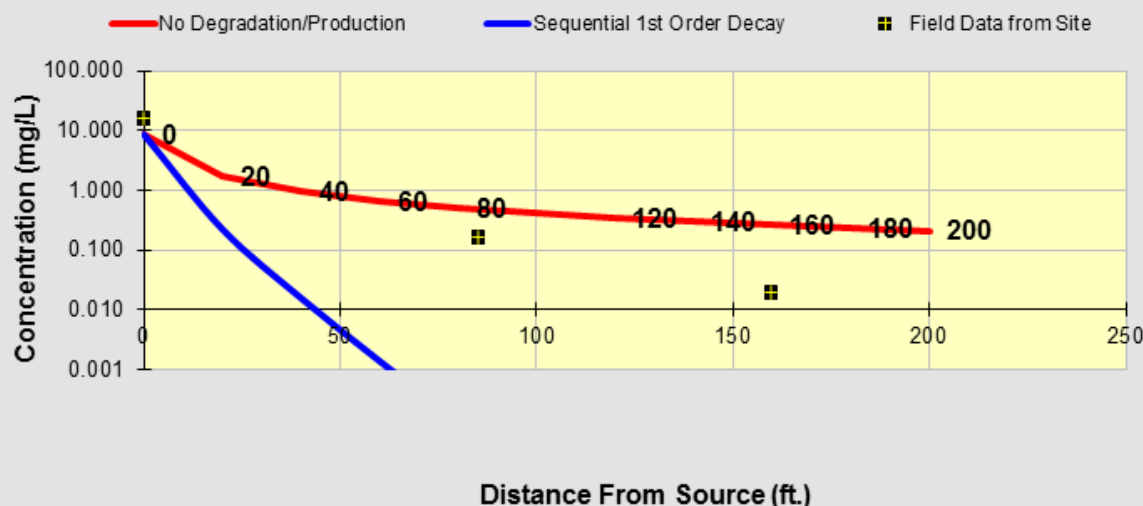
Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

Output screen for Low K BIOCHLOR TCE model with source concentrations taken from Table 2-10

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

TCE	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	8.650	1.760	0.975	0.673	0.514	0.416	0.349	0.301	0.264	0.236	0.213
Biotransformation	8.6500	0.224	0.016	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Field Data from Site	Monitoring Well Locations (ft)										
	0	10	20	40	60	85	100	120	140	160	220
Field Data from Site	16.000					0.165				0.019	



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

100.0 Years

Log ↔ Linear

Unprotect
Sheet

Return to
Input

To All

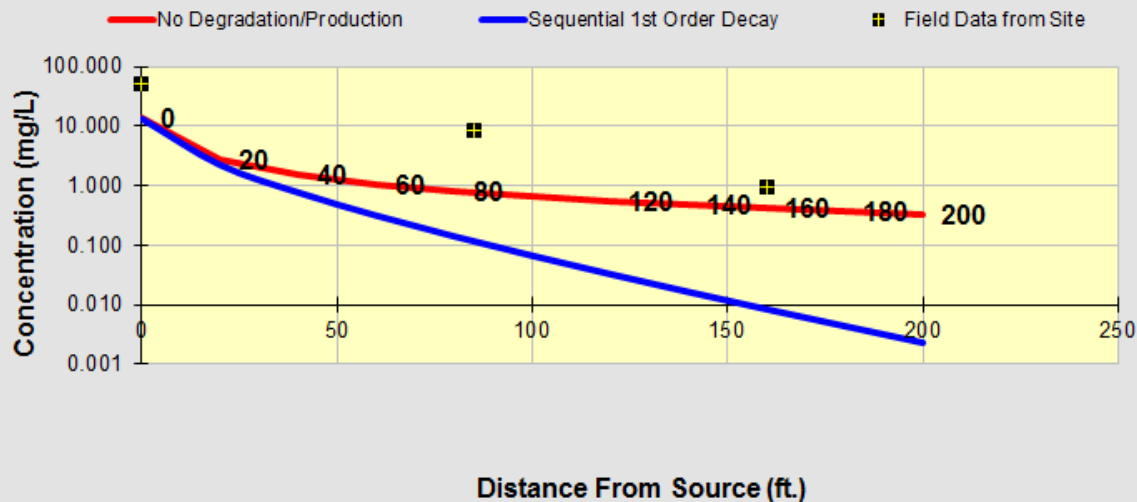
To Array

Output screen for Low K BIOCHLOR DCE model with source concentrations taken from Table 2-10

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

DCE	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	13.400	2.727	1.510	1.043	0.797	0.645	0.541	0.466	0.410	0.365	0.329
Biotransformation	13.4000	2.247	0.772	0.315	0.141	0.066	0.032	0.016	0.008	0.004	0.002

Field Data from Site	Monitoring Well Locations (ft)										
	0	10	20	40	60	85	100	120	140	160	220
Field Data from Site	50.000					8.200				0.960	



See PCE
See TCE
See DCE
See VC
See ETH

Prepare Animation

Time:

100.0 Years

Log ↔ Linear

Unprotect
Sheet

Return to
Input

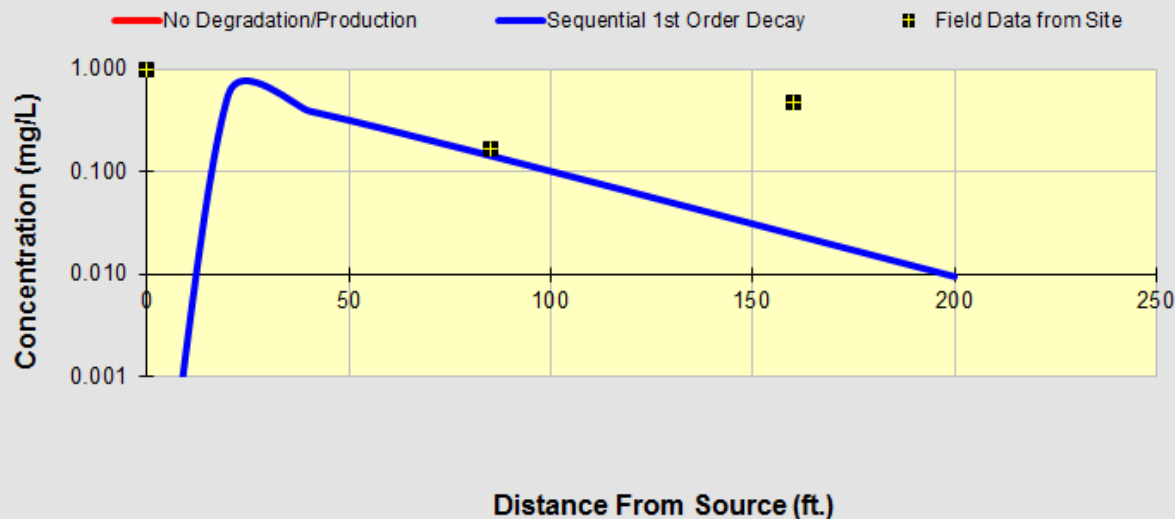
To All

To Array

Output screen for Low K BIOCHLOR VC model with source concentrations taken from Table 2-10

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

VC	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biotransformation	0.0000	0.558	0.393	0.255	0.162	0.101	0.063	0.039	0.025	0.015	0.009
Field Data from Site	Monitoring Well Locations (ft)										
	0	10	20	40	60	85	100	120	140	160	220
	1.000					0.165				0.480	



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

100.0 Years

Log ↔ Linear

Unprotect
Sheet

Return to
Input

To All

To Array

Input screen for Low K BIOCHLOR

Naphthalene model run with source concentration taken from Table 2-10

BIOCHLOR Natural Attenuation Decision Support System

Version 2.2

Excel 2000

CRS_SVOC

MW-14A to MW-11A

Run Name

Data Input Instructions:

1. Enter value directly....or
 2. Calculate by filling in gray cells. Press Enter, then **C**
- (To restore formulas, hit "Restore Formulas" button)
Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT:

Ethenes ☒
Ethanes ☐

1. ADVECTION

Seepage Velocity* Vs 11.0 (ft/yr) **C**
Hydraulic Conductivity K 3.4E-05 (cm/sec)
Hydraulic Gradient i 0.0628 (ft/ft)
Effective Porosity n 0.2 (-)



2. DISPERSION

Alpha x* 50 (ft)
(Alpha y) / (Alpha x)* 0.1 (-)
(Alpha z) / (Alpha x)* 1.E-02 (-)
Calc. Alpha x

3. ADSORPTION

Retardation Factor* R **C**
Soil Bulk Density, rho 1 (kg/L)
Fraction Organic Carbon, foc 0.0E+0 (-)
Partition Coefficient Koc
PCE 426 (L/kg) 1.00 (-)
TCE 130 (L/kg) 1.00 (-)
DCE 125 (L/kg) 1.00 (-)
VC 30 (L/kg) 1.00 (-)
ETH 302 (L/kg) 1.00 (-)
Common R (used in model)* = 1.00

4. BIOTRANSFORMATION

Zone 1 
PCE → TCE 6.000 (1/yr) half-life (yrs) 0.79
TCE → DCE 0.000 (1/yr) half-life (yrs) 0.74
DCE → VC 0.000 (1/yr) half-life (yrs) 0.64
VC → ETH 0.000 (1/yr) half-life (yrs) 0.45
Zone 2 
PCE → TCE 0.000 (1/yr) half-life (yrs)
TCE → DCE 0.000 (1/yr) half-life (yrs)
DCE → VC 0.000 (1/yr) half-life (yrs)
VC → ETH 0.000 (1/yr) half-life (yrs)

5. GENERAL

Simulation Time* 100 (yr)
Modeled Area Width* 200 (ft)
Modeled Area Length* 200 (ft)
Zone 1 Length* 200 (ft)
Zone 2 Length* 0 (ft)
Zone 2 = L - Zone 1

6. SOURCE DATA

Source Options
Source Thickness in Sat. Zone* 5 (ft)
Y1
Width* (ft) 10
Conc. (mg/L)* C1
PCE 3.43
TCE
DCE
VC
ETH

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L) 7.405 .052 .011
TCE Conc. (mg/L)
DCE Conc. (mg/L)
VC Conc. (mg/L)
ETH Conc. (mg/L)
Distance from Source (ft) 0 10 20 40 60 85 100 120 140 160 220
Date Data Collected 2011

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

RUN ARRAY

Help

Restore

RESET

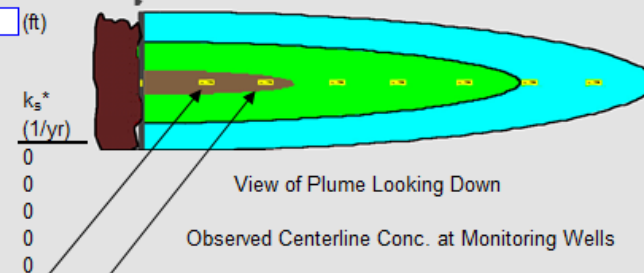
SEE OUTPUT

Paste

Unprotect

TYPE: Continuous
Single Planar

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations

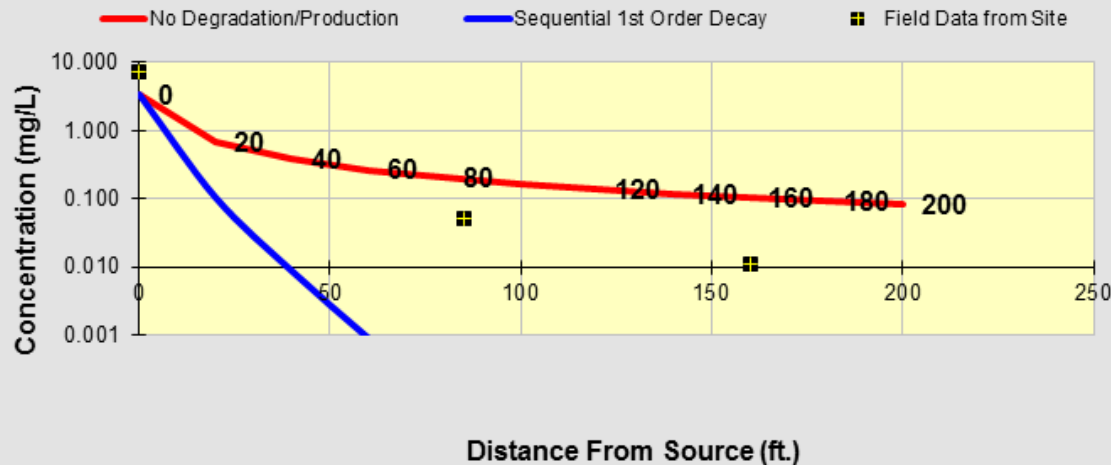


Output screen for Low K BIOCHLOR Naphthalene model with source concentrations taken from Table 2-10

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

Formula Bar

PCE	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	3.430	0.698	0.386	0.267	0.204	0.165	0.138	0.119	0.105	0.093	0.084
Biotransformation	3.4300	0.105	0.009	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Monitoring Well Locations (ft)										
	0	10	20	40	60	85	100	120	140	160	220
Field Data from Site	7.405					0.052				0.011	



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

100.0 Years

Log ↔ Linear

Unprotect
Sheet

Return to
Input

To All

To Array

Input screen for Low K BIOSCREEN

Benzene model run with source concentration taken from Table 2-10

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence

Version 1.4

CRS
Benzene
Run Name

Data Input Instructions:

115 or 0.02

1. Enter value directly...or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* 20 → Data used directly in model.
Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity* Vs 11.1 (ft/yr)
or
Hydraulic Conductivity K 3.4E-05 (cm/sec)
Hydraulic Gradient i 0.0628 (ft/ft)
Porosity n 0.2 (-)

2. DISPERSION

Longitudinal Dispersivity* alpha x 50.0 (ft)
Transverse Dispersivity* alpha y 5.0 (ft)
Vertical Dispersivity* alpha z 0.1 (ft)
or
Estimated Plume Length Lp 200 (ft)

3. ADSORPTION

Retardation Factor* R 1.0 (-)
or
Soil Bulk Density rho 1.7 (kg/l)
Partition Coefficient Koc 38 (L/kg)
Fraction Organic Carbon foc 5.7E-5 (-)

4. BIODEGRADATION

1st Order Decay Coeff* lambda 5.6E-1 (per yr)
or
Solute Half-Life t-half (year)
or Instantaneous Reaction Model

Delta Oxygen* DO (mg/L)
Delta Nitrate* NO3 (mg/L)
Observed Ferrous Iron* Fe2+ (mg/L)
Delta Sulfate* SO4 (mg/L)
Observed Methane* CH4 (mg/L)

5. GENERAL

Modeled Area Length* 200 (ft)
Modeled Area Width* 200 (ft)
Simulation Time* 100 (yr)

6. SOURCE DATA

Source Thickness in Sat. Zone* 5 (ft)

Source Zones:

Width* (ft)	Conc. (mg/L)*
4	1.92
4	1.92
4	1.92
4	1.92
4	1.92

Source Half-life (see Help):
>1000 >1000 (yr)
Inst. React. 1st Order
Soluble Mass 46000 (Kg)
In Source NAPL, Soil

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	6.3				.84				.62	
Dist. from Source (ft)	0	20	40	60	85	100	120	140	160	200

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

View Output

RUN ARRAY

View Output

Help

Recalculate This Sheet

Paste Example Dataset

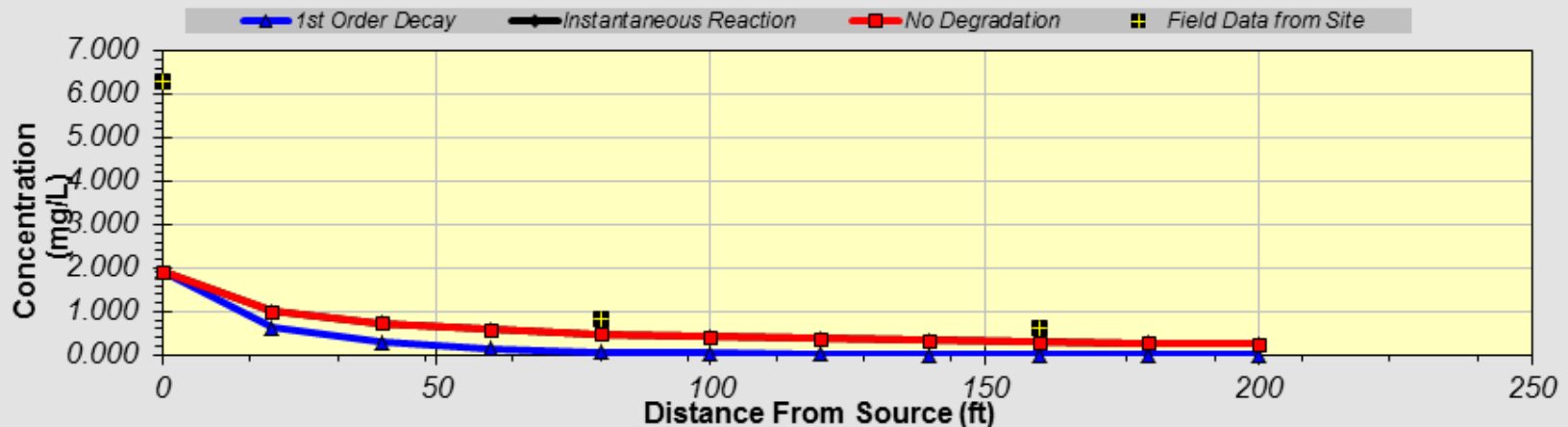
Restore Formulas for Vs, Dispersivities, R, lambda, other

Output screen for Low K BIOSCREEN

Benzene model with source concentrations taken from Table 2-10

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	1.920	0.998	0.726	0.583	0.489	0.422	0.371	0.331	0.298	0.272	0.249
1st Order Decay	1.920	0.627	0.286	0.144	0.076	0.041	0.023	0.013	0.007	0.004	0.002
Inst. Reaction	1.920	0.998	0.726	0.583	0.489	0.422	0.371	0.331	0.298	0.272	0.249
Field Data from Site	6.300				0.840				0.620		



Calculate
Animation

Time:

100 Years

Return to
Input

Recalculate This
Sheet

Input screen for Low K BIOSCREEN

Toluene model run with source concentration taken from Table 2-10

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence

Version 1.4

CRS
Toluene
Run Name

Data Input Instructions:

115
↑ or
0.02

1. Enter value directly...or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* → Data used directly in model.
20 → Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity* Vs 11.1 (ft/yr)
or
Hydraulic Conductivity K 3.4E-05 (cm/sec)
Hydraulic Gradient i 0.0628 (ft/ft)
Porosity n 0.2 (-)

2. DISPERSION

Longitudinal Dispersivity* alpha x 50.0 (ft)
Transverse Dispersivity* alpha y 5.0 (ft)
Vertical Dispersivity* alpha z 0.1 (ft)
or
Estimated Plume Length Lp 200 (ft)

3. ADSORPTION

Retardation Factor* R 1.0 (-)
or
Soil Bulk Density rho 1.7 (kg/l)
Partition Coefficient Koc 38 (L/kg)
Fraction Organic Carbon foc 5.7E-5 (-)

4. BIODEGRADATION

1st Order Decay Coeff* lambda 9.5E+0 (per yr)
or
Solute Half-Life t-half 0.08 (year)
or Instantaneous Reaction Model

Delta Oxygen* DO (mg/L)
Delta Nitrate* NO3 (mg/L)
Observed Ferrous Iron* Fe2+ (mg/L)
Delta Sulfate* SO4 (mg/L)
Observed Methane* CH4 (mg/L)

5. GENERAL

Modeled Area Length* 200 (ft)
Modeled Area Width* 200 (ft)
Simulation Time* 100 (yr)

6. SOURCE DATA

Source Thickness in Sat Zone* 5 (ft)

Source Zones:

Width* (ft)	Conc. (mg/L)*
4	13.2
4	13.2
4	13.2
4	13.2
4	13.2

Source Half-life (see Help):
>1000 >1000 (yr)
Inst React. 1st Order
Soluble Mass 46000 (Kg)
In Source NAPL, Soil

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	40.0				.68				.12		
Dist. from Source (ft)	0	20	40	60	85	100	120	140	160	180	200

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

View Output

RUN ARRAY

View Output

Help

Recalculate This Sheet

Paste Example Dataset

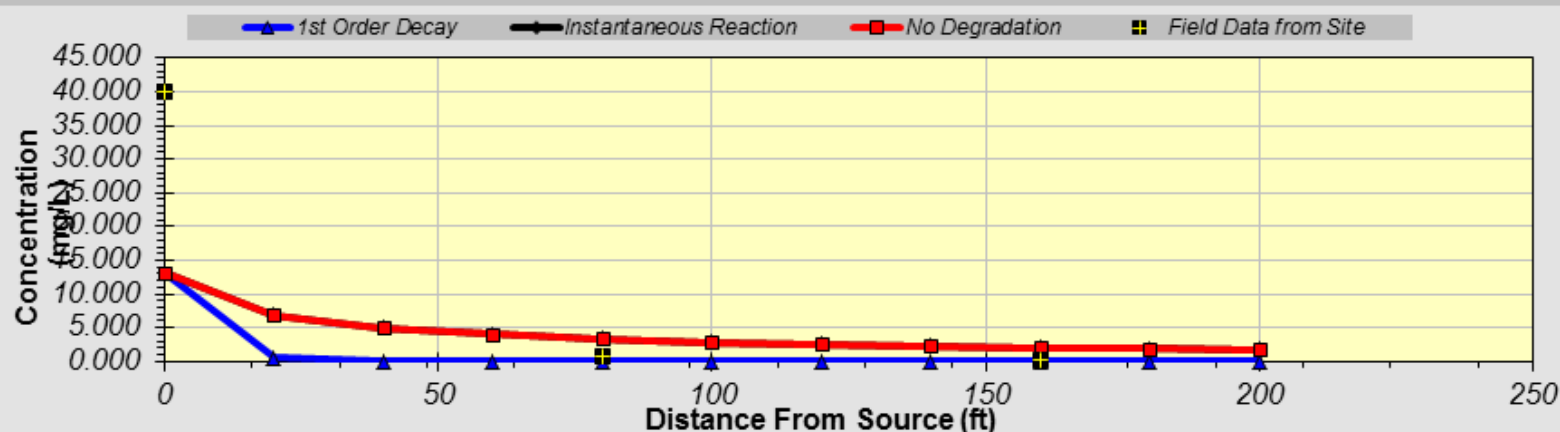
Restore Formulas for Vs, Dispersivities, R, lambda, other

Output screen for Low K BIOSCREEN

Toluene model with source concentrations taken from Table 2-10

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	13.198	6.863	4.988	4.007	3.362	2.899	2.548	2.272	2.050	1.868	1.714
1st Order Decay	13.198	0.608	0.039	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Inst. Reaction	13.198	6.863	4.988	4.007	3.362	2.899	2.548	2.272	2.050	1.868	1.714
Field Data from Site	40.000				0.680				0.120		



Calculate Animation

Time:
100 Years

Return to Input

Recalculate This Sheet

Input screen for Low K BIOSCREEN

Ethylbenzene model run with source concentration taken from Table 2-10

BIOSCREEN Natural Attenuation Decision Support System
Air Force Center for Environmental Excellence

Version 1.4

CRS
Ethylbenzene
Run Name

Data Input Instructions:

115 or 0.02
Variable* 20
1. Enter value directly....or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).
Data used directly in model.
Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity* Vs 11.1 (ft/yr)
or
Hydraulic Conductivity K 3.4E-05 (cm/sec)
Hydraulic Gradient i 0.0628 (ft/ft)
Porosity n 0.2 (-)

2. DISPERSION

Longitudinal Dispersivity* alpha x 50.0 (ft)
Transverse Dispersivity* alpha y 5.0 (ft)
Vertical Dispersivity* alpha z 0.1 (ft)
or
Estimated Plume Length Lp 200 (ft)

3. ADSORPTION

Retardation Factor* R 1.0 (-)
or
Soil Bulk Density rho 1.7 (kg/l)
Partition Coefficient Koc 38 (L/kg)
Fraction Organic Carbon foc 5.7E-5 (-)

4. BIODEGRADATION

1st Order Decay Coeff* lambda 9.0E-1 (per yr)
or
Solute Half-Life t-half 0.08 (year)
or Instantaneous Reaction Model

Delta Oxygen* DO (mg/L)
Delta Nitrate* NO3 (mg/L)
Observed Ferrous Iron* Fe2+ (mg/L)
Delta Sulfate* SO4 (mg/L)
Observed Methane* CH4 (mg/L)

5. GENERAL

Modeled Area Length* 200 (ft)
Modeled Area Width* 200 (ft)
Simulation Time* 100 (yr)

6. SOURCE DATA

Source Thickness in Sat.Zone* 5 (ft)

Source Zones:

Width* (ft)	Conc. (mg/L)*
4	0.707
4	0.707
4	0.707
4	0.707
4	0.707

Source Half-life (see Help):
>1000 >1000 (yr)
Inst. React. 1st Order
Soluble Mass 46000 (Kg)
In Source NAPL, Soil

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	1.1				.46				.086		
Dist. from Source (ft)	0	20	40	60	85	100	120	140	160	180	200

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE
View Output

RUN ARRAY
View Output

Help
Recalculate This Sheet
Paste Example Dataset
Restore Formulas for Vs, Dispersivities, R, lambda, other

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

View of Plume Looking Down

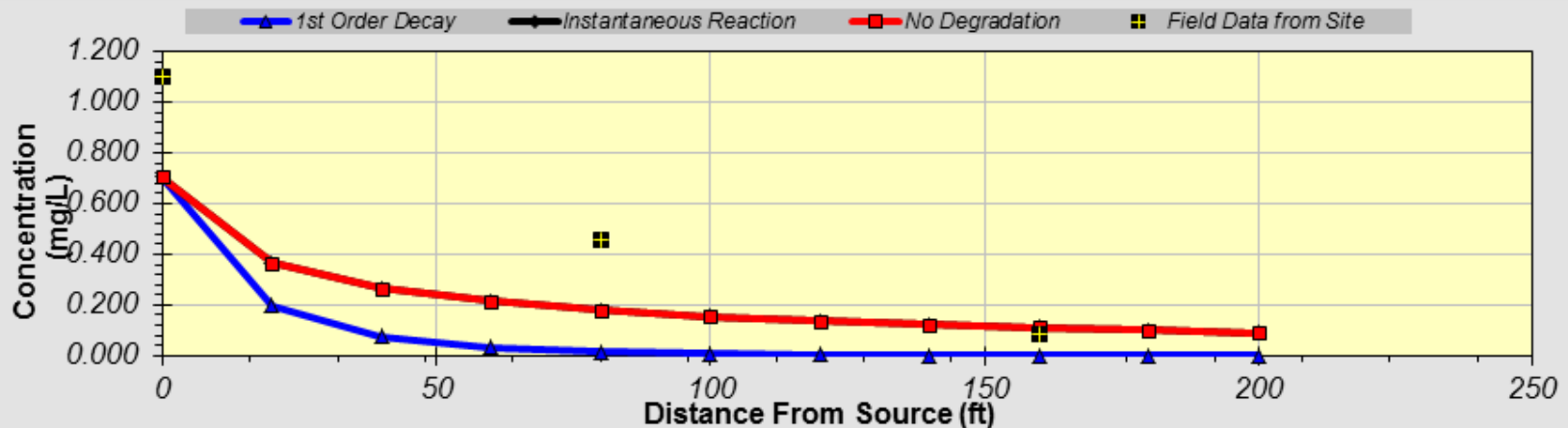
Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

Output screen for Low K BIOSCREEN

Ethylbenzene model with source concentrations taken from Table 2-10

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	0.707	0.368	0.267	0.215	0.180	0.155	0.136	0.122	0.110	0.100	0.092
1st Order Decay	0.707	0.196	0.076	0.032	0.015	0.007	0.003	0.001	0.001	0.000	0.000
Inst. Reaction	0.707	0.368	0.267	0.215	0.180	0.155	0.136	0.122	0.110	0.100	0.092
Field Data from Site	1.100				0.460				0.086		



Calculate
Animation

Time:

100 Years

Return to
Input

Recalculate This
Sheet

Input screen for Low K BIOSCREEN Total Xylenes model run with source concentration taken from Table 2-10

BIOSCREEN Natural Attenuation Decision Support System
Air Force Center for Environmental Excellence

Version 1.4

CRS
Total Xylenes
Run Name

Data Input Instructions:

1. Enter value directly...or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* → Data used directly in model.
20 → Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity* Vs 11.1 (ft/yr)
or
Hydraulic Conductivity K 3.4E-05 (cm/sec)
Hydraulic Gradient i 0.0628 (ft/ft)
Porosity n 0.2 (-)

2. DISPERSION

Longitudinal Dispersivity* alpha x 50.0 (ft)
Transverse Dispersivity* alpha y 5.0 (ft)
Vertical Dispersivity* alpha z 0.1 (ft)
or
Estimated Plume Length Lp 200 (ft)

3. ADSORPTION

Retardation Factor* R 1.0 (-)
or
Soil Bulk Density rho 1.7 (kg/l)
Partition Coefficient Koc 38 (L/kg)
Fraction Organic Carbon foc 5.7E-5 (-)

4. BIODEGRADATION

1st Order Decay Coeff* lambda 2.2E+0 (per yr)
or
Solute Half-Life t-half 0.08 (year)
or Instantaneous Reaction Model

Delta Oxygen* DO (mg/L)
Delta Nitrate* NO3 (mg/L)
Observed Ferrous Iron* Fe2+ (mg/L)
Delta Sulfate* SO4 (mg/L)
Observed Methane* CH4 (mg/L)

5. GENERAL

Modeled Area Length* 200 (ft)
Modeled Area Width* 200 (ft)
Simulation Time* 100 (yr)

6. SOURCE DATA

Source Thickness in Sat.Zone* 5 (ft)
Source Zones:

Width* (ft)	Conc. (mg/L)*
4	3.46
4	3.46
4	3.46
4	3.46
4	3.46

Source Halflife (see Help):
>1000 >1000 (yr)
Inst. React. 1st Order
Soluble Mass 46000 (Kg)
In Source NAPL, Soil

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	4.8				1.3				.18			
Dist. from Source (ft)	0	20	40	60	85	100	120	140	160	180	200	

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE
View Output

RUN ARRAY
View Output

Help
Recalculate This Sheet

Paste Example Dataset

Restore Formulas for Vs, Dispersivities, R, lambda, other

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

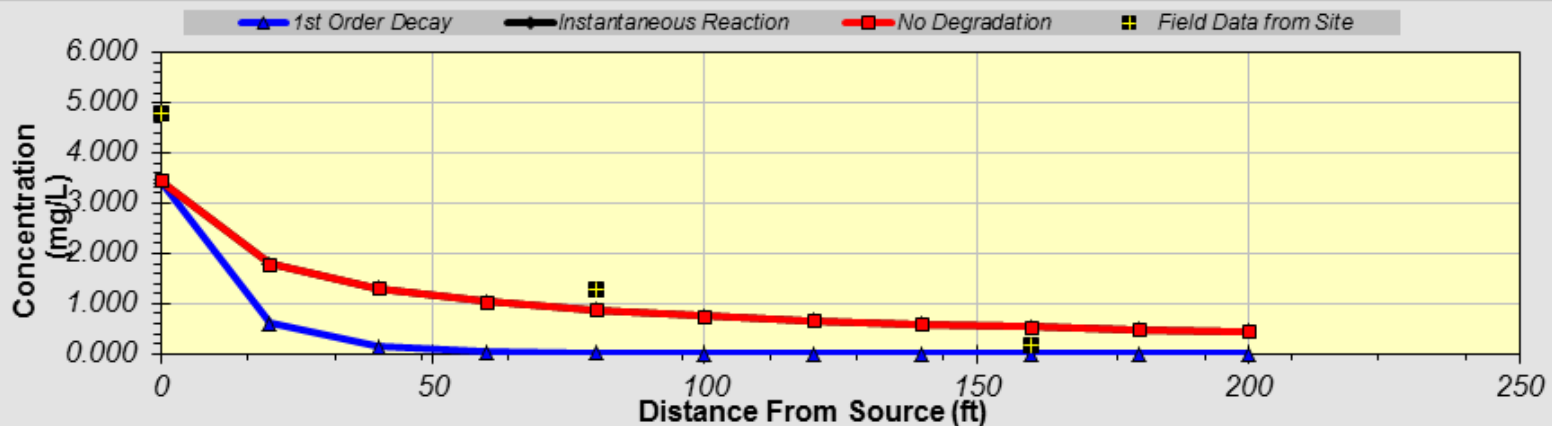
View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

Output screen for Low K BIOSCREEN Total Xylenes model with source concentrations taken from Table 2-10

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	3.460	1.799	1.308	1.050	0.881	0.760	0.668	0.596	0.538	0.490	0.449
1st Order Decay	3.460	0.614	0.152	0.042	0.012	0.004	0.001	0.000	0.000	0.000	0.000
Inst. Reaction	3.460	1.799	1.308	1.050	0.881	0.760	0.668	0.596	0.538	0.490	0.449
Field Data from Site	4.800				1.300				0.180		



Calculate Animation

Time:
100 Years

Return to Input

Recalculate This Sheet



BIOCHLOR / BIOSCREEN High K Simulations

LNAST FRACTURE FLOW

Input screen for High K BIOCHLOR TCE, DCE, and VC model runs with source concentrations taken from Table 2-10

BIOCHLOR Natural Attenuation Decision Support System

Version 2.2
Excel 2000

CRS

MW-14A to MW-11A

Run Name

Data Input Instructions:

1. Enter value directly....or
 2. Calculate by filling in gray cells. Press Enter, then **C**
- (To restore formulas, hit "Restore Formulas" button)
Variable* → Data used directly in model.

Test if
Biotransformation
is Occurring →

Natural Attenuation
Screening Protocol

TYPE OF CHLORINATED SOLVENT:

Ethenes ☒
Ethenes ☐

1. ADVECTION

Seepage Velocity* Vs 812.2 (ft/yr) **C**
Hydraulic Conductivity K 2.5E-03 (cm/sec)
Hydraulic Gradient i 0.0628 (ft/ft)
Effective Porosity n 0.2 (-)

2. DISPERSION

Alpha x* 50 (ft)
(Alpha y) / (Alpha x)* 0.1 (-)
(Alpha z) / (Alpha x)* 1.E-02 (-)
Calc. Alpha x

3. ADSORPTION

Retardation Factor* R **C**
Soil Bulk Density, rho 1 (kg/L)
Fraction Organic Carbon, f_{oc} 0.0E+0 (-)
Partition Coefficient K_{oc}
PCE 426 (L/kg) 1.00 (-)
TCE 130 (L/kg) 1.00 (-)
DCE 125 (L/kg) 1.00 (-)
VC 30 (L/kg) 1.00 (-)
ETH 302 (L/kg) 1.00 (-)
Common R (used in model)* = 1.00

4. BIOTRANSFORMATION

Zone 1
PCE → TCE 0.000 (1/yr) half-life (yrs) 0.79
TCE → DCE 7.000 (1/yr) half-life (yrs) 0.74
DCE → VC 0.700 (1/yr) half-life (yrs) 0.64
VC → ETH 0.500 (1/yr) half-life (yrs) 0.45
Zone 2
PCE → TCE 0.000 (1/yr) half-life (yrs) 0.79
TCE → DCE 0.000 (1/yr) half-life (yrs) 0.74
DCE → VC 0.000 (1/yr) half-life (yrs) 0.64
VC → ETH 0.000 (1/yr) half-life (yrs) 0.45

5. GENERAL

Simulation Time* 100 (yr)
Modeled Area Width* 200 (ft)
Modeled Area Length* 200 (ft)
Zone 1 Length* 200 (ft)
Zone 2 Length* 0 (ft)
Zone 2 = L - Zone 1

6. SOURCE DATA

Source Options
Source Thickness in Sat. Zone* 5 (ft)
Width* (ft) 10
Conc. (mg/L)* C1
PCE .0
TCE 8.65
DCE 13.4
VC .0
ETH .0

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L) 1.0
TCE Conc. (mg/L) 16.0
DCE Conc. (mg/L) 50.0
VC Conc. (mg/L) 1.0
ETH Conc. (mg/L) .0
Distance from Source (ft) 0 10 20 40 60 85 100 120 140 160 220
Date Data Collected 2011

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN
CENTERLINE

RUN ARRAY

Help

Restore

RESET

SEE
OUTPUT

Paste

Unprotect

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations

View of Plume Looking Down

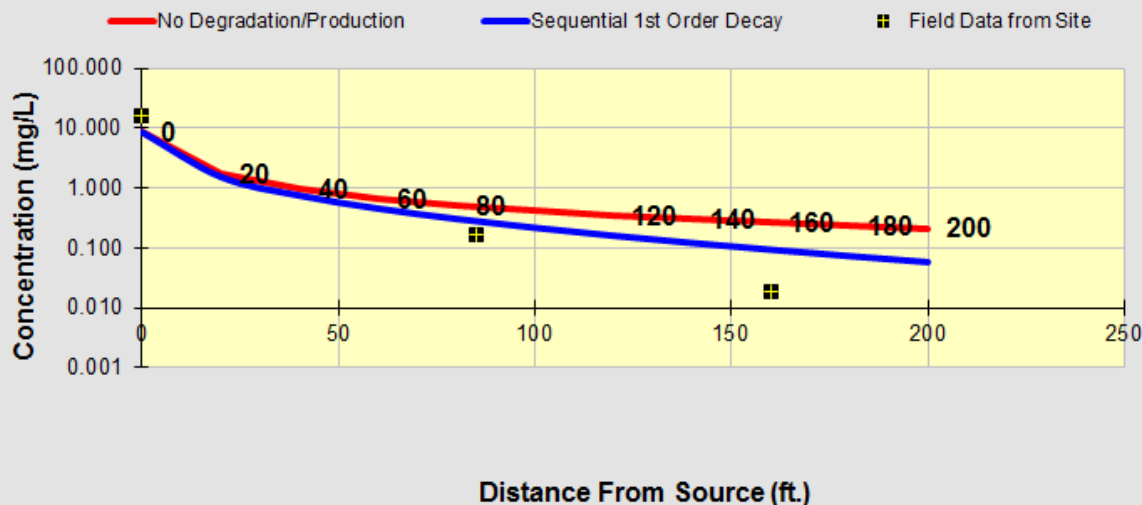
Observed Centerline Conc. at Monitoring Wells

Output screen for High K BIOCHLOR TCE model with source concentrations taken from Table 2-10

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

TCE	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	8.650	1.760	0.975	0.674	0.514	0.416	0.349	0.301	0.264	0.236	0.213
Biotransformation	8.6500	1.546	0.751	0.456	0.306	0.217	0.160	0.121	0.093	0.073	0.058

Field Data from Site	Monitoring Well Locations (ft)										
	0	10	20	40	60	85	100	120	140	160	220
Field Data from Site	16.000					0.165				0.019	



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

100.0 Years

Log \longleftrightarrow Linear

Unprotect Sheet

Return to Input

To All

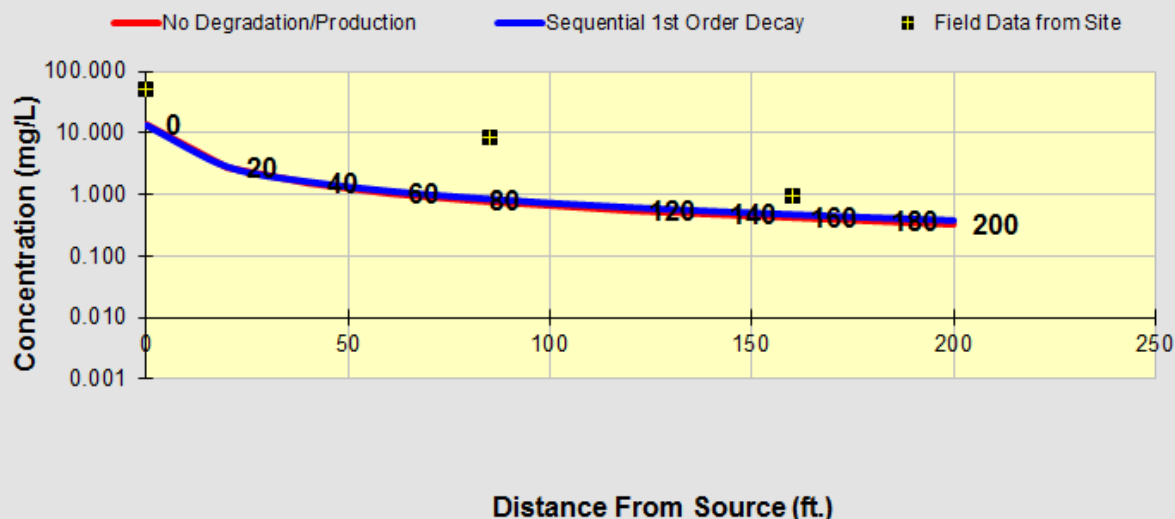
To Array

Output screen for High K BIOCHLOR DCE model with source concentrations taken from Table 2-10

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

DCE	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	13.400	2.727	1.510	1.043	0.797	0.645	0.541	0.466	0.410	0.365	0.330
Biotransformation	13.4000	2.834	1.618	1.144	0.890	0.729	0.618	0.536	0.472	0.421	0.380

Field Data from Site	Monitoring Well Locations (ft)										
	0	10	20	40	60	85	100	120	140	160	220
Field Data from Site	50.000					8.200				0.960	



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

100.0 Years

Log ↔ Linear

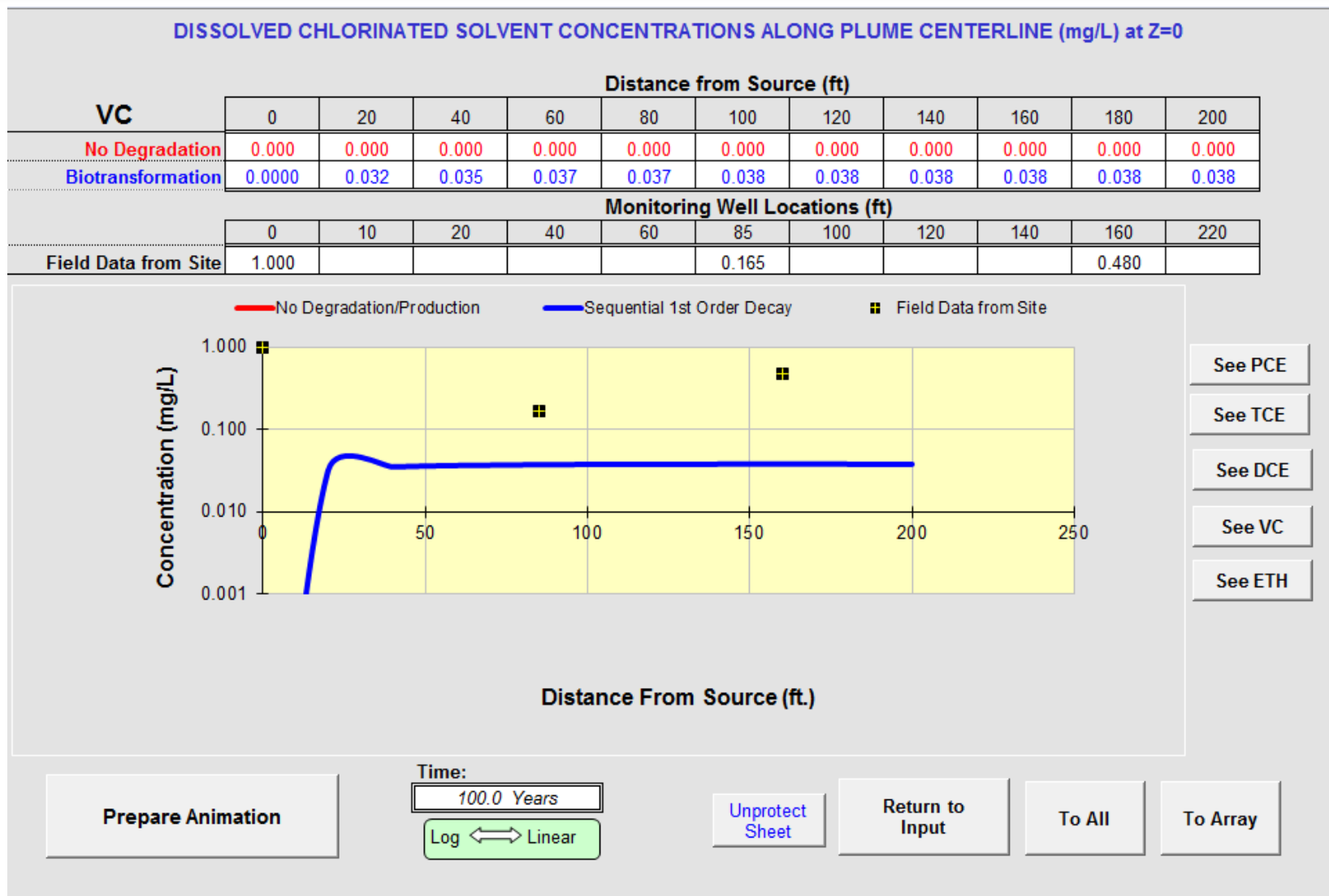
Unprotect Sheet

Return to Input

To All

To Array

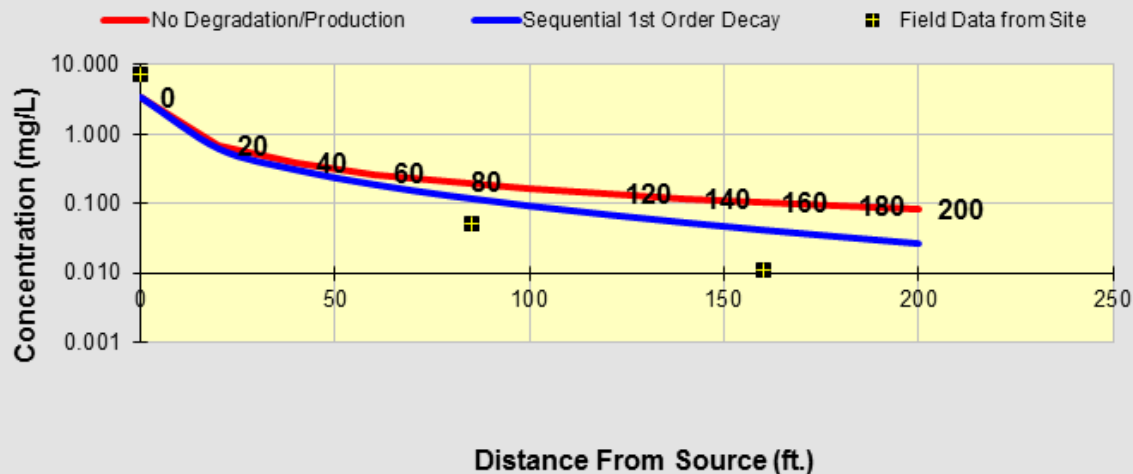
Output screen for High K BIOCHLOR VC model with source concentrations taken from Table 2-10



Output screen for High K BIOCHLOR Naphthalene model with source concentrations taken from Table 2-10

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

PCE	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	3.430	0.698	0.387	0.267	0.204	0.165	0.139	0.119	0.105	0.094	0.084
Biotransformation	3.4300	0.622	0.307	0.189	0.129	0.093	0.070	0.053	0.042	0.033	0.027
	Monitoring Well Locations (ft)										
	0	10	20	40	60	85	100	120	140	160	220
Field Data from Site	7.405					0.052				0.011	



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

100.0 Years

Log ↔ Linear

Unprotect
Sheet

Return to
Input

To All

To Array

Input screen for High K BIOSCREEN Benzene model run with source concentration taken from Table 2-10

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence

Version 1.4

CRS
Benzene
Run Name

1. HYDROGEOLOGY

Seepage Velocity* Vs 812.8 (ft/yr)
or
Hydraulic Conductivity K 2.5E-03 (cm/sec)
Hydraulic Gradient i 0.0628 (ft/ft)
Porosity n 0.2 (-)

2. DISPERSION

Longitudinal Dispersivity* alpha x 50.0 (ft)
Transverse Dispersivity* alpha y 5.0 (ft)
Vertical Dispersivity* alpha z 0.1 (ft)
or
Estimated Plume Length Lp 200 (ft)

3. ADSORPTION

Retardation Factor* R 1.0 (-)
or
Soil Bulk Density rho 1.7 (kg/l)
Partition Coefficient Koc 38 (L/kg)
Fraction Organic Carbon foc 5.7E-5 (-)

4. BIODEGRADATION

1st Order Decay Coeff* lambda 5.6E-1 (per yr)
or
Solute Half-Life t-half (year)
or Instantaneous Reaction Model

Delta Oxygen* DO (mg/L)
Delta Nitrate* NO3 (mg/L)
Observed Ferrous Iron* Fe2+ (mg/L)
Delta Sulfate* SO4 (mg/L)
Observed Methane* CH4 (mg/L)

5. GENERAL

Modeled Area Length* 200 (ft)
Modeled Area Width* 200 (ft)
Simulation Time* 100 (yr)

6. SOURCE DATA

Source Thickness in Sat Zone* 5 (ft)
Source Zones:

Width* (ft)	Conc. (mg/L)*
4	1.92
4	1.92
4	1.92
4	1.92
4	1.92

Source Halflife (see Help):
>1000 >1000 (yr)
Inst. React. 1st Order
Soluble Mass 46000 (Kg)
In Source NAPL Soil

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	6.3			.84				.62			
Dist. from Source (ft)	0	20	40	60	85	100	120	140	160	180	200

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE **RUN ARRAY**

View Output **View Output**

Help Recalculate This Sheet

Paste Example Dataset

Restore Formulas for Vs, Dispersivities, R, lambda, other

Data Input Instructions:

115 or 0.02

1. Enter value directly....or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* → Data used directly in model.
20 → Value calculated by model. (Don't enter any data).

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

View of Plume Looking Down

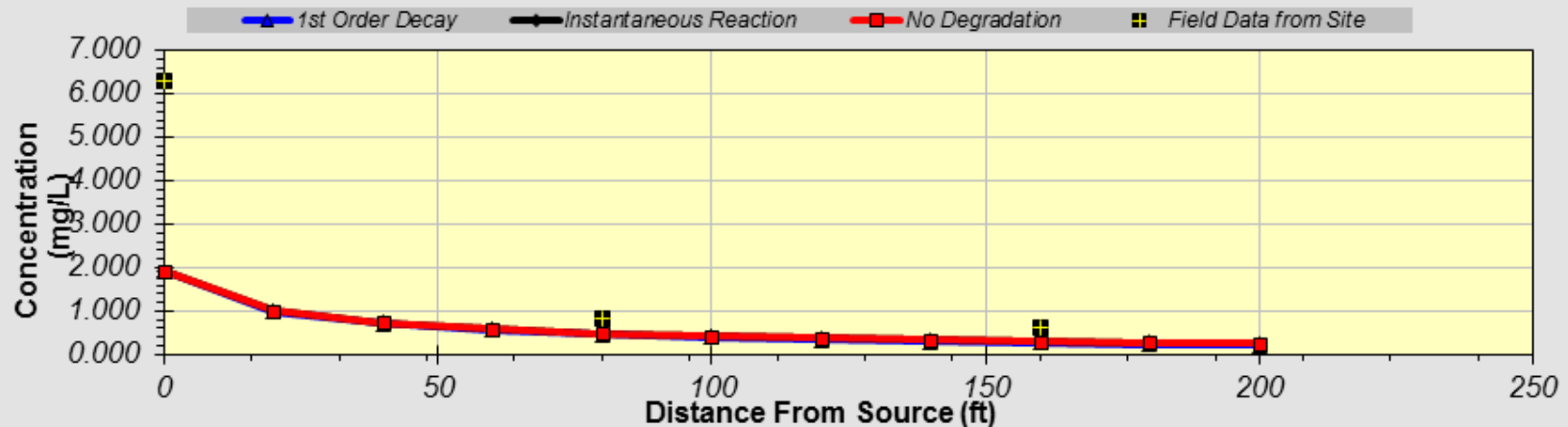
Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

Output screen for High K BIOSCREEN

Benzene model with source concentrations taken from Table 2-10

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	1.916	0.997	0.725	0.582	0.489	0.421	0.371	0.331	0.298	0.272	0.250
1st Order Decay	1.916	0.984	0.706	0.559	0.463	0.394	0.342	0.301	0.268	0.241	0.219
Inst. Reaction	1.916	0.997	0.725	0.582	0.489	0.421	0.371	0.331	0.298	0.272	0.250
Field Data from Site	6.300				0.840				0.620		



Calculate
Animation

Time:
100 Years

Return to
Input

Recalculate This
Sheet

Input screen for High K BIOSCREEN

Toluene model run with source concentration taken from Table 2-10

BIOSCREEN Natural Attenuation Decision Support System
Air Force Center for Environmental Excellence
Version 1.4

CRS
Toluene
Run Name

1. HYDROGEOLOGY
Seepage Velocity* Vs 812.8 (ft/yr)
or
Hydraulic Conductivity K 2.5E-03 (cm/sec)
Hydraulic Gradient i 0.0628 (ft/ft)
Porosity n 0.2 (-)

2. DISPERSION
Longitudinal Dispersivity* alpha x 50.0 (ft)
Transverse Dispersivity* alpha y 5.0 (ft)
Vertical Dispersivity* alpha z 0.1 (ft)
or
Estimated Plume Length Lp 200 (ft)

3. ADSORPTION
Retardation Factor* R 1.0 (-)
or
Soil Bulk Density rho 1.7 (kg/l)
Partition Coefficient Koc 38 (L/kg)
Fraction Organic Carbon foc 5.7E-5 (-)

4. BIODEGRADATION
1st Order Decay Coeff* lambda 9.5E+0 (per yr)
or
Solute Half-Life t-half 0.08 (year)
or Instantaneous Reaction Model
Delta Oxygen* DO (mg/L)
Delta Nitrate* NO3 (mg/L)
Observed Ferrous Iron* Fe2+ (mg/L)
Delta Sulfate* SO4 (mg/L)
Observed Methane* CH4 (mg/L)

5. GENERAL
Modeled Area Length* 200 (ft)
Modeled Area Width* 200 (ft)
Simulation Time* 100 (yr)

6. SOURCE DATA
Source Thickness in Sat Zone* 5 (ft)
Source Zones:
Width* (ft) Conc. (mg/L)*
4 13.2
4 13.2
4 13.2
4 13.2
4 13.2
Source Half-life (see Help):
>1000 >1000 (yr)
Inst React 1st Order
Soluble Mass 46000 (Kg)
In Source NAPL, Soil

7. FIELD DATA FOR COMPARISON
Concentration (mg/L) 40.0 .68 .12
Dist. from Source (ft) 0 20 40 60 85 100 120 140 160 180 200

8. CHOOSE TYPE OF OUTPUT TO SEE:
RUN CENTERLINE View Output
RUN ARRAY View Output

Data Input Instructions:
115 or 0.02
Variable* 20
1. Enter value directly.... or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).
Data used directly in model.
Value calculated by model. (Don't enter any data).

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

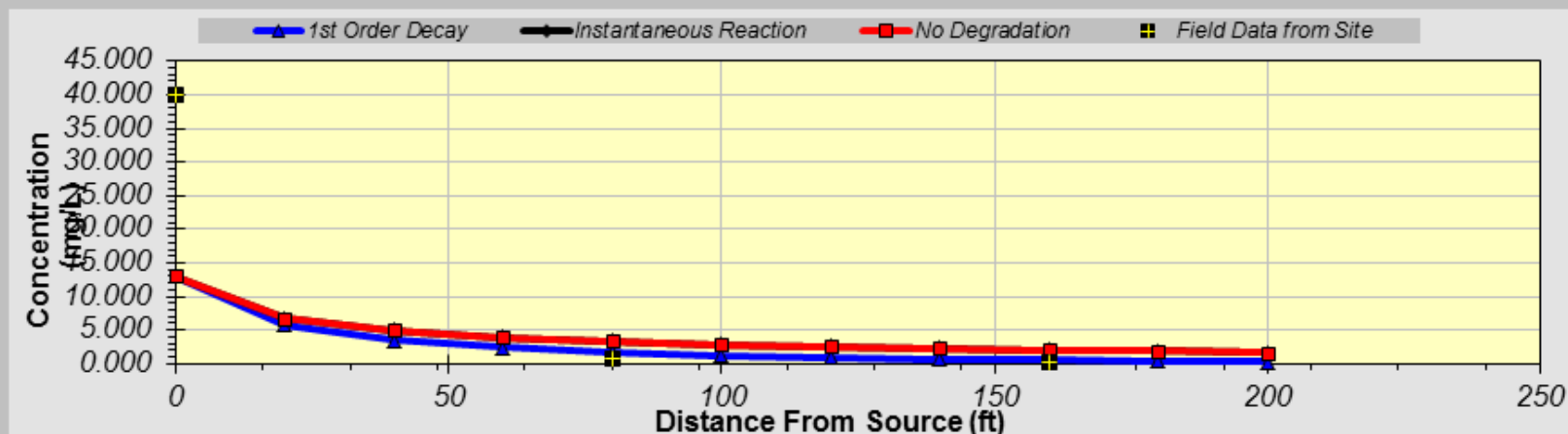
Help Recalculate This Sheet
Paste Example Dataset
Restore Formulas for Vs, Dispersivities, R, lambda, other

Output screen for High K BIOSCREEN

Toluene model with source concentrations taken from Table 2-10

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	13.027	6.778	4.926	3.958	3.322	2.865	2.519	2.247	2.028	1.848	1.698
1st Order Decay	13.027	5.745	3.539	2.410	1.714	1.253	0.934	0.706	0.540	0.417	0.325
Inst. Reaction	13.027	6.778	4.926	3.958	3.322	2.865	2.519	2.247	2.028	1.848	1.698
Field Data from Site	40.000				0.680				0.120		



Calculate
Animation

Time:
100 Years

Return to
Input

Recalculate This
Sheet

Input screen for High K BIOSCREEN

Ethylbenzene model run with source concentration taken from Table 2-10

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence

Version 1.4

CRS

Ethylbenzene

Run Name

Data Input Instructions:

115

or

0.02

1. Enter value directly...or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* → Data used directly in model.
20 → Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity* Vs 812.8 (ft/yr)
or
Hydraulic Conductivity K 2.5E-03 (cm/sec)
Hydraulic Gradient i 0.0628 (ft/ft)
Porosity n 0.2 (-)

2. DISPERSION

Longitudinal Dispersivity* alpha x 50.0 (ft)
Transverse Dispersivity* alpha y 5.0 (ft)
Vertical Dispersivity* alpha z 0.1 (ft)
or
Estimated Plume Length Lp 200 (ft)

3. ADSORPTION

Retardation Factor* R 1.0 (-)
or
Soil Bulk Density rho 1.7 (kg/l)
Partition Coefficient Koc 38 (L/kg)
Fraction Organic Carbon foc 5.7E-5 (-)

4. BIODEGRADATION

1st Order Decay Coeff* lambda 9.0E-1 (per yr)
or
Solute Half-Life t-half 0.08 (year)
or Instantaneous Reaction Model
Delta Oxygen* DO (mg/L)
Delta Nitrate* NO3 (mg/L)
Observed Ferrous Iron* Fe2+ (mg/L)
Delta Sulfate* SO4 (mg/L)
Observed Methane* CH4 (mg/L)

5. GENERAL

Modeled Area Length* 200 (ft)
Modeled Area Width* 200 (ft)
Simulation Time* 100 (yr)

6. SOURCE DATA

Source Thickness in Sat Zone* 5 (ft)

Source Zones:

Width* (ft)	Conc. (mg/L)*
4	0.707
4	0.707
4	0.707
4	0.707
4	0.707

Source Half-life (see Help):

>1000 >1000 (yr)

Inst. React. ↑ 1st Order

Soluble Mass 46000 (Kg)

In Source NAPL, Soil

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	1.1				.46					.086		
Dist. from Source (ft)	0	20	40	60	85	100	120	140	160	180	200	

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN
CENTERLINE

RUN ARRAY

View Output

View Output

Help

Recalculate
This Sheet

Paste Example Dataset

Restore Formulas for Vs,
Dispersivities, R, lambda, other

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

View of Plume Looking Down

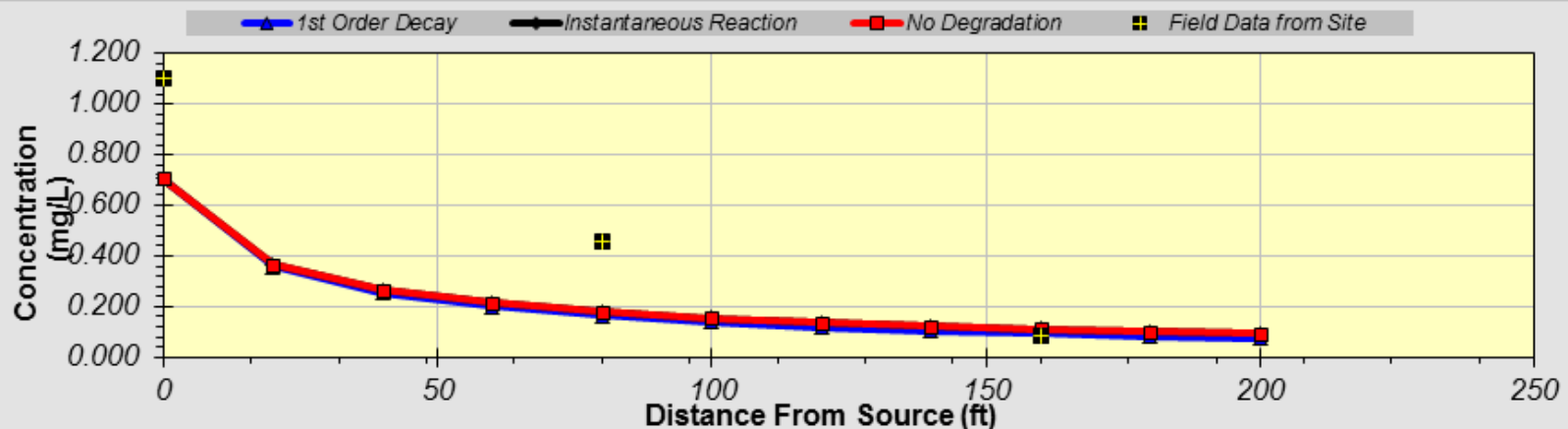
Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

Output screen for High K BIOSCREEN

Ethylbenzene model with source concentrations taken from Table 2-10

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	0.707	0.368	0.267	0.215	0.180	0.155	0.137	0.122	0.110	0.100	0.092
1st Order Decay	0.707	0.360	0.256	0.202	0.166	0.140	0.120	0.105	0.093	0.083	0.075
Inst. Reaction	0.707	0.368	0.267	0.215	0.180	0.155	0.137	0.122	0.110	0.100	0.092
Field Data from Site	1.100				0.460				0.086		



Calculate Animation

Time:

100 Years

Return to Input

Recalculate This Sheet

Input screen for High K BIOSCREEN Total Xylenes model run with source concentration taken from Table 2-10

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence

Version 1.4

CRS

Total Xylenes

Run Name

Data Input Instructions:

115

↑ or

0.02

1. Enter value directly...or
 2. Calculate by filling in grey cells below. (To restore formulas, hit button below).
- Variable* → Data used directly in model.
- 20 → Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity* Vs 812.8 (ft/yr)
 or
 Hydraulic Conductivity K 2.5E-03 (cm/sec)
 Hydraulic Gradient i 0.0628 (ft/ft)
 Porosity n 0.2 (-)

2. DISPERSION

Longitudinal Dispersivity* alpha x 50.0 (ft)
 Transverse Dispersivity* alpha y 5.0 (ft)
 Vertical Dispersivity* alpha z 0.1 (ft)
 or
 Estimated Plume Length Lp 200 (ft)

3. ADSORPTION

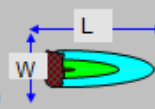
Retardation Factor* R 1.0 (-)
 or
 Soil Bulk Density rho 1.7 (kg/l)
 Partition Coefficient Koc 38 (L/kg)
 Fraction Organic Carbon foc 5.7E-5 (-)

4. BIODEGRADATION

1st Order Decay Coeff* lambda 2.2E+0 (per yr)
 or
 Solute Half-Life t-half 0.08 (year)
 or Instantaneous Reaction Model
 Delta Oxygen* DO (mg/L)
 Delta Nitrate* NO3 (mg/L)
 Observed Ferrous Iron* Fe2+ (mg/L)
 Delta Sulfate* SO4 (mg/L)
 Observed Methane* CH4 (mg/L)

5. GENERAL

Modeled Area Length* 200 (ft)
 Modeled Area Width* 200 (ft)
 Simulation Time* 100 (yr)



6. SOURCE DATA

Source Thickness in Sat Zone* 5 (ft)

Source Zones:

Width* (ft)	Conc. (mg/L)*
4	3.46
4	3.46
4	3.46
4	3.46
4	3.46

Source Half-life (see Help):

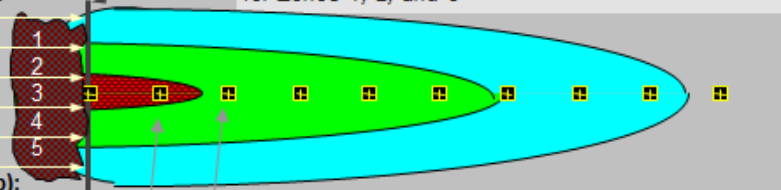
>1000 >1000 (yr)

Inst. React. ↑ 1st Order

Soluble Mass 46000 (Kg)

In Source NAPL, Soil

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
 If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	4.8				1.3				.18			
Dist. from Source (ft)	0	20	40	60	85	100	120	140	160	180	200	

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

RUN ARRAY

View Output

View Output

Help

Recalculate This Sheet

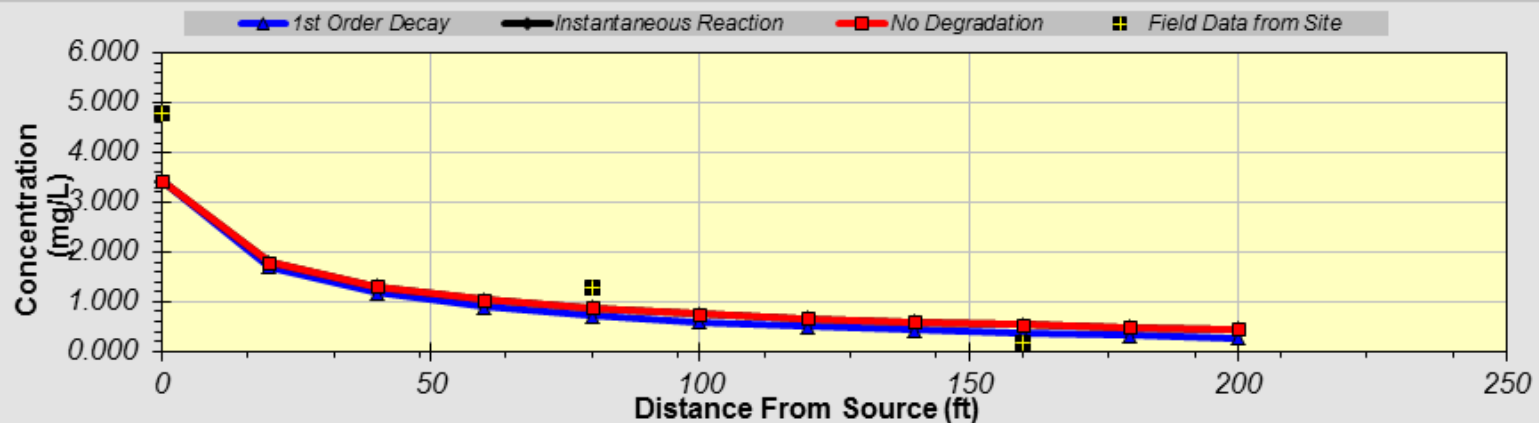
Paste Example Dataset

Restore Formulas for Vs, Dispersivities, R, lambda, other

Output screen for High K BIOSCREEN Total Xylenes model with source concentrations taken from Table 2-10

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	20	40	60	80	100	120	140	160	180	200
No Degradation	3.448	1.794	1.304	1.048	0.879	0.758	0.667	0.595	0.537	0.489	0.449
1st Order Decay	3.448	1.709	1.184	0.906	0.725	0.596	0.499	0.424	0.365	0.317	0.277
Inst. Reaction	3.448	1.794	1.304	1.048	0.879	0.758	0.667	0.595	0.537	0.489	0.449
Field Data from Site	4.800				1.300				0.180		



Calculate Animation

Time:

100 Years

Return to Input

Recalculate This Sheet

Attachment 2

Revised Table 3-1 – which has been revised to Table 3-1a and Table 3-1b

Table 3.1a List of Constituents, ARARs, and TBCs

Constituent	Identified in Record of Decision (ROD)	USEPA Maximum Contaminant Levels (µg/L)	Ohio Generic Unrestricted Potable Water Use Standards (µg/L)	Ohio MCLs (µg/L)	USEPA Regional Screening Levels - Tapwater (µg/L)
Volatile Organic Compounds					
Acetone	No	-	14,000 **	-	12,000
Benzene	Yes	5	5	5	0.39
2-Butanone	No	-	8,900 **	-	4,900
Carbon tetrachloride	No	5	5	5	0.39
Chloroethane	Yes	-	550 **	-	21,000
Chloroform	Yes	-	40 **	-	0.19
Cyclohexane	No	-	-	-	13,000
Dibromochloromethane	Yes	-	19 **	-	0.15
1,1 Dichloroethane	Yes	5	250 **	-	2.4
1,2 Dichloroethane	Yes	-	5	5	0.15
1,1 Dichloroethene	Yes	7	7	7	260
Cis 1,2 Dichloroethene	Yes	70	70	70	28
Trans 1,2 Dichloroethene	Yes	100	100	100	86
trans 1,3 Dichloropropene ¹	Yes	5	16 **	-	0.41
Ethylbenzene	Yes	700	700	700	1.3
2-Hexanone	No	-	-	-	34
Isopropylbenzene	No	-	-	-	390
4-Methyl-2-pentanone	No	-	1,200 **	-	1,000
Methylene Chloride	Yes	-	5	-	9.9
Methylcyclohexane	No	-	-	-	-
Styrene	Yes	1,000	100	100	1,100
Tetrachloroethene	Yes	5	5	-	9.7
Toluene	Yes	1,000	1,000	1,000	860
1,1,1-Trichloroethane	Yes	200	200	200	7,500
1,1,2 Trichloroethane	Yes	5	5	5	0.24
Trichloroethene	Yes	2	5	5	0.44
1,2,4-Trimethylbenzene	No	-	140 **	-	15
1,3,5-Trimethylbenzene	No	-	140 **	-	87
Vinyl Chloride	Yes	2	2	0.2	0.015
Xylene	Yes	10,000	10,000	10,000	190
Semi-Volatile Organic Compounds					
Anthracene	No	-	4,700 **	-	1,300
Acenaphthylene ²	No	-	470 **	-	87
Acetophenone	No	-	1,600 **	-	1,500
Benzo(a)pyrene	Yes	2	0.2	0.2	0.0029
Benzo(a) anthracene	Yes	2	0.63 **	-	0.029
Benzo(b)fluoranthene	Yes	2	0.46 **	-	0.029
1,1'-Biphenyl	No	-	-	-	0.83
Bis(2-ethylhexyl)phthalate	No	6	6	-	4.8
Carbazole	No	-	79 **	-	-
Chrysene	No	-	63 **	-	2.9
Dibenzo(a,h) anthracene	Yes	2	-	-	0.0029
Dibenzofuran	No	-	-	-	5.8
2,4-Dimethylphenol	No	-	310 **	-	270
Fluoranthene	No	-	420 **	-	630
Fluorene	Yes	2	630 **	-	220
Indeno(1,2,3cd) pyrene	Yes	2	0.34 **	-	0.029
Isophorone	Yes	2	1,700 **	-	67
2-Methylnaphthalene	No	-	-	-	27
2-Methylphenol	No	-	790 **	-	720
3 & 4 Methylphenol ³	No	-	-	-	1,400
Naphthalene	Yes	2	67 **	-	0.14
Phenanthrene ²	No	-	470 **	-	87
Phenol	No	-	4,700 **	-	4,500
Pyrene	No	-	470 **	-	87

Table 3.1a List of Constituents, ARARs, and TBCs

Constituent	Identified in Record of Decision (ROD)	USEPA Maximum Contaminant Levels (µg/L)	Ohio Generic Unrestricted Potable Water Use Standards (µg/L)	Ohio MCLs (µg/L)	USEPA Regional Screening Levels - Tapwater (µg/L)
Metals					
Aluminum	No	-	-	-	16,000
Antimony	No	6	6	-	6
Arsenic	Yes	10	10	10	0.045
Barium	No	2,000	2,000	-	2,900
Beryllium	No	4	4	-	16
Cadmium	No	5	5	-	6.9
Calcium	No	-	-	-	-
Chromium	No	100	100	-	16,000
Cobalt	No	-	320 **	-	4.7
Iron	Yes	-	-	-	11,000
Magnesium	No	-	-	-	-
Manganese	Yes	50 *	-	50*	320
Nickel	No	-	320 **	-	300
Potassium	No	-	-	-	-
Selenium	No	50	50	-	78
Sodium	No	-	-	-	-
Thallium	No	2	2	-	0.16
Vanadium	No	-	130 **	-	78
Zinc	No	-	4,700 **	-	4,700
PCBs					
Aroclors 1016	Yes	0.5	0.5	0.5	0.96
Aroclors 1221	Yes	0.5	0.5	0.5	0.004
Aroclors 1232	Yes	0.5	0.5	0.5	0.004
Aroclors 1242	Yes	0.5	0.5	0.5	0.034
Aroclors 1248	Yes	0.5	0.5	0.5	0.034
Aroclors 1254	Yes	0.5	0.5	0.5	0.034
Aroclors 1260	Yes	0.5	0.5	0.5	0.034

Notes:

- ' indicates no standard or screening level available; *Secondary MCL; ** Risk-Derived Generic Numerical Standard

1. Standard or screening level for total 1,3-dichloropropene presented.

2. Standard or screening level for pyrene presented.

3. Standard or screening level for cresols presented.

USEPA. 2009. Maximum Contaminant Levels. May 2009. Available online at: <http://water.epa.gov/drink/contaminants/index.cfm>
Last accessed: 02/04/2013.

Ohio Environmental Protection Agency. Drinking Water Standards for Ohio Public Water Systems. November 26, 2010.
Ohio Administrative Code Chapter 3745-81

USEPA. 2012. Regional Screening Levels. November 2012.

Available online at: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm Last accessed: 02/04/2013

Ohio EPA. Generic numerical standards. Ohio Administrative Code. 3745-300-08 Tables V and VI, Generic numerical standards for unrestricted potable water use.

Table 3.1b Rationale for Inclusion in TI Waiver

Constituent	ARAR/TBC	Source	Maximum Detected Concentration (µg/L)	Maximum Detection Limit (µg/L)	Latest Groundwater Data Exceeds in TI Zone	Constituent to be Included in TI Waiver ³
Volatile Organic Compounds						
Acetone	14,000	Ohio GNS	41,000	33,000	Yes ^{1,2}	Yes
Benzene	5	USEPA MCL	49,000	2,500	Yes ^{1,2}	Yes
2-Butanone	8,900	Ohio GNS	34,000	33,000	Yes ^{1,2}	Yes
Carbon tetrachloride	5	USEPA MCL	980	3,300	Yes ^{1,2}	Yes
Chloroethane	550	Ohio GNS	99	3,300	ERLs	Yes
Chloroform	40	Ohio GNS	-	3,300	ERLs	Yes
Cyclohexane	13,000	USEPA RSL	270	3,300	No	No
Dibromochloromethane	19	Ohio GNS	-	2,500	ERLs	Yes
1,1 Dichloroethane	5	USEPA MCL	6,200	2,500	Yes ^{1,2}	Yes
1,2 Dichloroethane	5	Ohio GNS	600	3,300	Yes ^{1,2}	Yes
1,1 Dichloroethene	7	USEPA MCL	1,800	2,000	Yes ^{1,2}	Yes
Cis 1,2 Dichloroethene	70	USEPA MCL	81,000	10	Yes ²	Yes
Trans 1,2 Dichloroethene	100	USEPA MCL	5.5	3,300	ERLs	Yes
trans 1,3 Dichloropropene ⁴	5	USEPA MCL	340	3,300	Yes ^{1,2}	Yes
Ethylbenzene	700	USEPA MCL	3,100	33	Yes ²	Yes
2-Hexanone	34	USEPA RSL	700	33,000	Yes ^{1,2}	Yes
Isopropylbenzene	390	USEPA RSL	1.1	3,300	ERLs	Yes
4-Methyl-2-pentanone	1,200	Ohio GNS	9,000	25,000	Yes ^{1,2}	Yes
Methylene Chloride	5	Ohio GNS	33,000	3,300	Yes ^{1,2}	Yes
Methylcyclohexane	-		0.14	10	-	No
Styrene	1,000	USEPA MCL	3,300	830	Yes ²	Yes
Tetrachloroethene	5	USEPA MCL	31	3,300	Yes ¹	Yes
Toluene	1,000	USEPA MCL	92,000	33	Yes ²	Yes
1,1,1-Trichloroethane	200	USEPA MCL	23,000	63	Yes ²	Yes
1,1,2 Trichloroethane	5	USEPA MCL	-	2,500	ERLs	Yes
Trichloroethene	2	USEPA MCL	45,000	2,500	Yes ^{1,2}	Yes
1,2,4-Trimethylbenzene	140	Ohio GNS	240	-	Yes ²	Yes
1,3,5-Trimethylbenzene	140	Ohio GNS	150	-	Yes ²	Yes
Vinyl Chloride	2	USEPA MCL	480	3,300	Yes ¹	Yes
Xylene	10,000	USEPA MCL	6,100	33	No ²	No
Semi-Volatile Organic Compounds						
Anthracene	4,700	Ohio GNS	67	2,000	No ²	No
Acenaphthylene ⁵	470	Ohio GNS	490	50	Yes ²	Yes
Acetophenone	1,600	Ohio GNS	10	380	No	No
Benzo(a)pyrene	2	USEPA MCL	44	2,000	Yes ^{1,2}	Yes
Benzo(a) anthracene	2	USEPA MCL	44	2,000	Yes ^{1,2}	Yes
Benzo(b)fluoranthene	2	USEPA MCL	28	2,000	Yes ^{1,2}	Yes
1,1'-Biphenyl	0.83	USEPA RSL	6.2	380	Yes	Yes

Table 3.1b Rationale for Inclusion in TI Waiver

Constituent	ARAR/TBC	Source	Maximum Detected Concentration (µg/L)	Maximum Detection Limit (µg/L)	Latest Groundwater Data Exceeds in TI Zone	Constituent to be Included in TI Waiver ³
Bis(2-ethylhexyl)phthalate	6	USEPA MCL	1.1	2,000	Yes ¹	Yes
Carbazole	79	Ohio GNS	1.4	2,000	ERLs	Yes
Chrysene	63	Ohio GNS	36	2,000	ERLs ²	Yes
Dibenzo(a,h) anthracene	2	USEPA MCL	0.12	76	ERLs	Yes
Dibenzofuran	5.8	USEPA RSL	0.31	2,000	ERLs	Yes
2,4-Dimethylphenol	310	Ohio GNS	2.7	2,000	ERLs	Yes
Fluoranthene	420	Ohio GNS	110	2,000	ERLs ²	Yes
Fluorene	2	USEPA MCL	540	76	Yes ^{1,2}	Yes
Indeno(1,2,3cd) pyrene	2	USEPA MCL	17	2,000	Yes ^{1,2}	Yes
Isophorone	2	USEPA MCL	1,500	380	Yes ¹	Yes
2-Methylnaphthalene	27	USEPA RSL	610	10	Yes ²	Yes
2-Methylphenol	790	Ohio GNS	2.7	2,000	ERLs	Yes
3 & 4 Methylphenol ⁶	1,400	USEPA RSL	5.1	760	No	No
Naphthalene	2	USEPA MCL	8,800	6,000	Yes ^{1,2}	Yes
Phenanthrene ⁵	470	Ohio GNS	400	76	No ²	No
Phenol	4,700	Ohio GNS	33	2,000	No	No
Pyrene	470	Ohio GNS	150	2,000	ERLs ²	Yes
Metals						
Aluminum	16,000	USEPA RSL	588	-	No	No
Antimony	6	USEPA MCL	33.8	2	Yes	Yes
Arsenic	10	USEPA MCL	9	-	Yes	Yes
Barium	2,000	USEPA MCL	147	-	No	Yes
Beryllium	4	USEPA MCL	0.28	1	No ²	Yes
Cadmium	5	USEPA MCL	92.2	1	Yes	Yes
Calcium	-		186,000	-	-	No
Chromium	100	USEPA MCL	8.5	-	No	Yes
Cobalt	320	Ohio GNS	29.7	-	No ²	Yes
Iron	11,000	USEPA RSL	22,100	-	Yes ²	Yes
Magnesium	-		44,300	-	-	No
Manganese	50	USEPA MCL	10,400	-	Yes ²	Yes
Nickel	320	Ohio GNS	49.5	-	No	Yes
Potassium	-		18,800	-	-	No
Selenium	50	USEPA MCL	3.8	5	No	Yes
Sodium	-		575,000	-	-	No
Thallium	2	USEPA MCL	0.29	1	Yes	Yes
Vanadium	130	Ohio GNS	1.4	20	No	Yes
Zinc	4,700	Ohio GNS	1,580	-	No	Yes
PCBs						
Aroclors 1016	0.5	USEPA MCL	-	1	No ¹	Yes
Aroclors 1221	0.5	USEPA MCL	-	1	No ¹	Yes

Table 3.1b Rationale for Inclusion in TI Waiver

Constituent	ARAR/TBC	Source	Maximum Detected Concentration (µg/L)	Maximum Detection Limit (µg/L)	Latest Groundwater Data Exceeds in TI Zone	Constituent to be Included in TI Waiver ³
Aroclors 1232	0.5	USEPA MCL	-	1	No ¹	Yes
Aroclors 1242	0.5	USEPA MCL	-	1	No ¹	Yes
Aroclors 1248	0.5	USEPA MCL	-	1	No ¹	Yes
Aroclors 1254	0.5	USEPA MCL	-	1	No ¹	Yes
Aroclors 1260	0.5	USEPA MCL	-	1	No ¹	Yes

Notes:

-¹ indicates no standard or screening level available; *Secondary MCL; ** Risk-Derived Generic Numerical Standard; ERLs = elevated reporting limits

1. Reporting Limits exceed MCL in other select samples.

2. Sample potentially contained trace NAPL

3. Rationale for waiver of ARARs for constituent includes listing as COPC in ROD and detection or reporting limits above MCLs in groundwater sample collected from proposed TI Waiver area.

4. Standard or screening level for total 1,3-dichloropropene presented.

5. Standard or screening level for pyrene presented.

6. Standard or screening level for cresols presented.

USEPA. 2009. Maximum Contaminant Levels. May 2009. Available online at: <http://water.epa.gov/drink/contaminants/index.cfm> Last accessed: 02/04/Ohio Environmental Protection Agency. Drinking Water Standards for Ohio Public Water Systems. November 26, 2010.

Ohio Administrative Code Chapter 3745-81

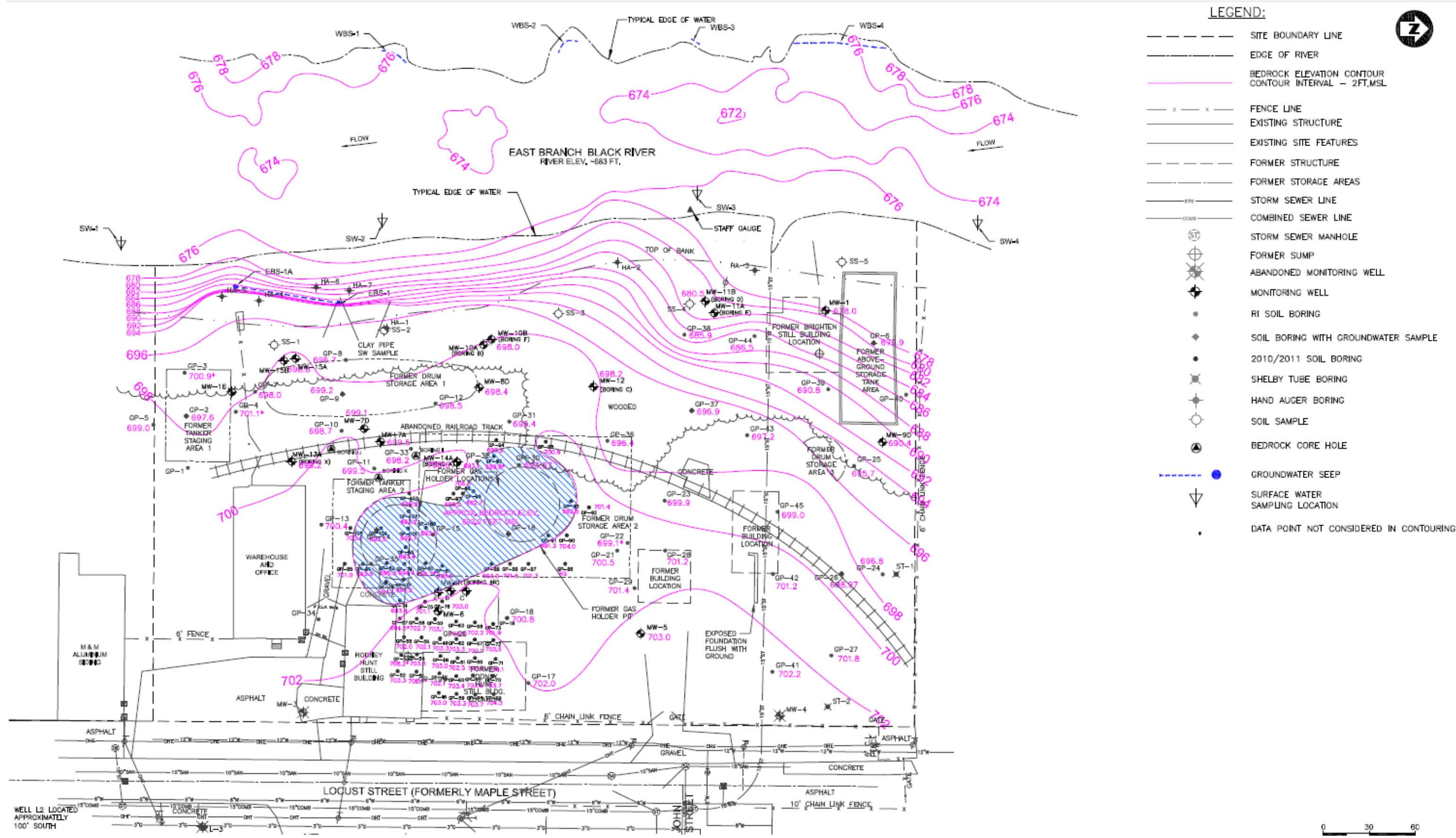
USEPA. 2012. Regional Screening Levels. November 2012.

Available online at: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm Last accessed: 02/04/2013

Ohio EPA. Generic numerical standards. Ohio Administrative Code. 3745-300-08 Tables V and VI, Generic numerical standards for unrestricted potable water use.

Attachment 3

Figure 4-2



TOP OF BEDROCK ELEVATION (GENERALIZED)
(FROM BROWN AND CALDWELL, 2012)

FIGURE
4-2